Mutah University
College of Graduate Studies

Evaluation of the Quality and Pretreatment of Industrial Wastewater in Selective Factories in AL-Hussein Bin Abdullahll Industrial City .

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Dedication

To the light of my path,
To my father
Wonderful Mother
And my uncles and my aunt
To my great love Marwah
And to all My Friends
May God Bless Them.

Marwan Murad Ali

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Abbreviations

Symbols	Definition
°C	degrees Celsius
µs/cm	Micro Siemens per centimeter
BOD5	five-day Biochemical Oxygen Demand
C	Concentration
Ca	Calcium
Cl	Chloride
COD	Chemical Oxygen Demand
R1	Reactor1
R2	Reactor2
Cr	Chromium
Cu	Copper
DW	Distilled Water
EC	Electric Conductivity
CF	Clothes Factory
HF	Halvah Factory
HUIE	AL-Hussein Bin Abdullahll Industrial City
IWW	Industrial Waste Water
IWTS	Industrial Wastewater Treatment System
EPA	Environmental Protection Agency
F^-	Fluoride
Fe	Iron
JIEC	Jordan Industrial Estates Corporation
Mg	Magnesium
Mn	Manganese
ms/cm	Millisiemens per centimeter
Na	Sodium
ND	Not Detected
NO_3	Nitrate
Pb	Lead
pH	Negative logarithm of H^+ concentration
POTW	Publicly owned treatment works
SAR	Sodium Adsorption Ratio
SO_4	Sulphate
TDS	Total dissolved Solids
TOC	Total organic carbon
TSS	Total Suspended Solids
WHO	World Health Organization
Zn	Zinc
TVSS	Total volatile suspended solid

Abstract

Evaluation of the Quality and Pretreatment of Industrial Wastewater in Selective Factories in AL-Hussein Bin Abdullahll Industrial City .

Marwan Murad Ali
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Evaluation and improvement of the quality of the effluent industrial wastewater (IWW) produced from factories at AL-Hussein Bin Abdullahll Industrial City were performed. The study comprised suggestion of anaerobic oxidation and coagulation treatment methods to improve the quality of produced IWW. The quality parameters of raw IWW and treated IWW were determined. The parameters included Physical parameters (Total suspended solids TSS, Temperature (T), Total dissolved solids TDS, Total volatile solids TVS). Chemical parameters (pH, Electrical conductivity EC, TOC, COD and BOD_5), Heavy metals (Pb, Mn , Fe, Cr , Zn and Cu). The removal efficiencies using anaerobic treatment for different parameters are (84.913%, 51.67%, 67.63%, 57.86%, 48%) for COD, BOD, TOC, TSS, TVS respectively (61%, 45.21% and 66 % , 49.8% , 71% , 61.3%) for Pb, Fe, Cu, Zn, Cr, Mn respectively for clothes factory and removal efficiency for halvah factory (65% , 25.04% , 67.64% , 36.25% ,39%) for COD, BOD5, TOC, TSS, TVS respectively (54% , 73.4%, 53 % , 30% , 36.5% , 57%) for Pb, Fe, Cu, Zn, Cr and Mn respectively.

The second method of treatment effluent IWW from factories is sedimentation by using alum by different concentration (0,6.667,33.335 and 66.67ppm) for coagulant , after analysis laboratory for this wastewater the result showed decrease of organic matter and heavy metals 40% of COD, (29% , 41% , 48% , 33%) for Pb, Fe, Cu and Cr respectively.

The results showed that anaerobic oxidation treatment can be used effectively and economically for pretreatment of industrial wastewater (IWW) before disposal to the treatment plant .

الملخص

تقييم الجودة والمعالجة الأولية للمياه العادمة الصناعية في مصانع انتقائية في مدينة الحسين بن عبد الله الثاني الصناعية.

مروان مراد علي عجة

جامعة مؤتة، 2016

شملت الدراسة تقييم الجودة للمياه العادمة الصناعية الخارجة من مصانع مختارة في مدينة الحسين بن عبد الله الثاني الصناعية. تضمنت الدراسة قياس بعض الخصائص الفيزيائية والكيميائية للمياه الخارجة من المصانع وكذلك خصائص المياه المعالجة مثل (درجة الحموضة، تركيز المواد ألصلبه العالقة، درجه الحرارة والموصلية الكهربائية، المعادن الثقيلة (الرصاص، المنغنيز، الحديد، الكروم، الخارصين والنحاس)، الأوكسجين المستهلك حيويا، الأوكسجين المستهلك كيميائيا و الكاربون العضوي الكلي. عملية المعالجة المستخدمة كانت باستخدام جهاز الهضم اللاهوائي، نتائج الفحوصات المختبرية بعد عملية المعالجة لعينة مياه مصنع الملابس بينت ان فعالية المعالجة كانت عالية حيث تم إزالة 84% من الأوكسجين المستهلك كيميائيا، 51.67% من الاوكسجين المستهلك حيويا، 67.63% للكاربون العضوي الكلي، 57.86% من المواد الصلبة العالقة، 48% من المواد الكلية المتطايرة، 61% من عنصر الرصاص، 45.21% من عنصر الحديد، 66% من النحاس، 49.8% من الخارصين، 71% الكروم، 61.3% من المنغنيز. أما كفاءة المعالجة لعينة مياه مصنع الحلاوة و الطحينية كانت بالشكل التالي 65% الاوكسجين المستهلك كيميائيا، 25.04% الاوكسجين المستهلك حيويا، 67.64% من الكاربون العضوي الكلي، 36.25% من المواد الصلبة العالقة، 39% المواد المتطايرة الكلية، 54% عنصر الرصاص، 73.4% من الحديد، 53% من النحاس، 30% من الخارصين، 36.5% من الكروم، 57% من المنغنيز. الطريقة الثانية المستخدمة كمعالجة أولية للمياه العادمة الصناعية هي طريقة الترسيب باستخدام مادة الشب حيث أضفنا أربع تراكيز مختلفة من مادة الشب إلى أربع عينات من المياه وتم دراسة كل عينة حيث بينت النتائج المختبرية انخفاض بالمواد العضوية والعناصر الثقيلة حيث كانت كفاءة الإزالة كالتالي 40% من الأوكسجين المستهلك كيميائيا، 29% من الرصاص، 41% من الحديد، 48% من النحاس، 33% من الكروم.

النتائج بينت أن المعالجة اللاهوائية يمكن استخدامها لأنها فعالة وأكثر اقتصادية لمعالجة مياه الصناعية الأسنة قبل طرحها إلى محطة المعالجة .

Chapter One

1.1 -Introduction :

There are four types of wastewater depending on there sources, domestic sewage, industrial wastewater, agricultural runoff, and storm water. Increase in the world's population, placed pressure on the industries to reclaim and reuse some of there wastewater to save more fresh water. This was due to the combined pressures of increasing water and wastewater costs and increasing regulatory requirements of discharged wastewater. Industrial wastewater causes serious environmental problems due to its high color, large amount of suspended solids (SS), and high chemical oxygen demand (COD) (Kim *et al*., 2008). The characteristics of industrial wastewater can differ considerably both within and among industries. The quality of industrial wastewater (IWW) depends on the nature of raw materials used in the industry, therefore, IWW has different characteristics. The clothes and food industries are demand large quantities of water, and produce large amounts of wastewater. Waste stream generated in these industries is essentially based on water-based effluent generated in the various activities of wet processing . The main cause of generation of this effluent is the use of huge volume of water either in the actual chemical processing or during re-processing in preparatory, (Ling, 2009). clothes and food industries involve wide range of raw materials, machineries and processes to engineer the required shape and properties of the final product (Heinrich, 2003). Three options are available in controlling industrial wastewater. Control can take place at the point of generation in the plant; wastewater can be pretreated for discharge to municipal treatment plant; or wastewater can be treated completely at the plant and either reused or discharged directly into receiving waters. Selection of a wastewater treatment process or sequence of processes depends on a number of factors, i.e., characteristics of the wastewater, e.g., BOD,SS, pH ..etc, cost and availability of land, e.g., certain biological processes (stabilization ponds) are only economically feasible if low-cost land is available, consideration of a possible future upgrading of water quality standards, necessitating design of a more sophisticated type of treatment for future use. Different treatment processes depending on the characteristics of IWW are required for their treatment. Typical techniques include the classical methods such as adsorption, coagulation, ion exchange, flotation and sedimentation. All these techniques are versatile and useful, but they all end up in producing a secondary waste product which needs to be processed further. The characteristics of IWW produced in selective factories located in the (Al-Hussein Bin Abdullah II Industrial City) will be investigated. The factories to be selected are those

which produce wastewater having negative impact on the performance of the existing treatment plant, the factories to be included in the study are: Camel global company for the clothing industry; Zitouna company for the manufacture of ready-made clothes; Al-Flak company for the clothing industry; Kam AL-Sham Food Industries Company; AL-Majed factory for the manufacture of halva. Increasing volumes of wastewater combined with limited space availability and progressively tightening environmental standards have promoted the development of new intensive biotechnological processes for wastewater treatment. The pretreatment used in this study is the anaerobic treatment. Anaerobic treatment processes involve bacteria which function only in the absence of air. The anaerobic digester comprises two 5 litre upward-flow packed bed reactors with feed rate and temperature control facilities to allow steady, continuous operation at up to seven litres per day over periods of many days. The reactor operated in series. A buffer vessel between the reactors permits discharge of excess flow from the first reactor when the second reactor is operated in series but at a lower flow rate. The flow rates to the vessels are set and controlled by calibrated peristaltic pumps. The temperature of each reactor is controlled by an electric heating mat wrapped around the external wall. The temperature distribution within each reactor is maintained to ±0.5C. Reactor temperatures may be separately set at any desired value in the range ambient to 55ºC. The gas off-take from each reactor is taken to a volumetrically calibrated collector vessel operating by water displacement. A constant head, liquid seal device ensures that the gas pressure in the reactor is maintained at a constant value throughout the test run. The collected gas can be exhausted from the vessel and the volume re-filled with water during a run without breaking the liquid seal. Liquid and gas sampling points are located at all strategic points around the reactors. Non-return valves and liquid seal syphon breaks are included in the process pipework to ensure each reactor operates at a constant volume without the ingress of air or the danger of accidental syphonic action. The equipment is mounted on a vacuum formed plastic base with an integral drain channel to cope with spillages and wash down. These processes are becoming more popular in the water treatment industry as they have considerable advantage over aerobic processes, including low sludge production, tolerance of stop/start operation, production of a useful fuel (methane) and relatively high throughput (armfield).

1.2 Water Resource in Jordan

Jordan is classified as a Mediterranean semiarid climatic zone which is characterized by low rain-fall and high percentage of evaporation; about 92.2% of the rain fall evaporates, 5.4% recharges the ground water and 2.6% goes to the surface water (Ammary,2012). Water resource depend on rainfall which varies in quantites , intensity and distribution different from year to year , with most falls between the months of October and May. The average annual rainfall varies in Jordan ; on high land it is about 600-400mm , Jordan valley 300-50mm, and desert area (Badia) 50-200mm (91.4%).(ACWUA 2011) . According to the world wide norms, Jordan is suffering from water scarcity since the acceptable annual per capita water scarcity threshold is (1000m3), while in Jordan the available water resource per capita are estimated to be 180m3 yr-1(Ammary,2012). This is very low compared with the middle-east and north Africa annual average of 1200m3yr-1and worldwide average 7500m3yr-1(METAB,2013).the demand on water is dramatically increased in Jordan as a consequence of the natural population growth, industrialization, irrigation projects, higher standard of living, in addition to the effect of influx and migration of displaced people coming to Jordan from neighboring areas due to political situation in the Middle-East area.

Agricultural irrigation is the primary water consuming sector following by the municipal and industrial sectors; agriculture consumes (62.6%) of water resources,(33%) for municipal sector and (4%) for industrial sector(WAJ,2009). However, it is expected that by 2020 the amount of fresh water allocated for irrigation will drop in order to meet the increased water demand of municipal and industrial consumers(METAB,2013). Approximately 780 million cubic meters (MCM) per year is the available fresh water resources in Jordan for 2012 including both surface water and ground water, with total average surface flow of 505MCM per year and about 273MCM came from eleven ground water basins. Ground water extraction developed rapidly in the 1980 as the government freely awarded licenses for tube wells, as a result by the mid of 1980s a pattern of systematic overdrawing of ground water had been established so water levels in the main aquifers are declining due to this over exploitation, with some aquifers showing considerable deterioration in water quality due to salinity. There is also an annual abstraction of 65MCM of fossil water mostly from Disi in the southern part of the kingdom, the non-renewable ground water sources is being used for irrigation and water supply for Aqaba. About 18MCM extracted from the Jafer basin which is another non-renewable ground water source that is estimated to run dry in 40 years.

Therefore, the government of Jordan has developed a national master plan for reclaimed water reuse, since about 86MCM annually discharged

from 28 existing waste water treatment plants as a non conventional source of water which is used for irrigation mostly in Jordan valley. It is expected that 237MCM of treated waste water will be available for reuse by 2020(METAB,2013).

1.3 IWW treatment plant in Industrial City

The treatment plant in AL-Hussein Bin Abdullahll industrial city it is dependent on biological treatment, the treatment plant designed by flow (800) cubic meter per day, the treatment IWW used by irrigation.

Part of the IWW treatment plant

1. Screens
2. Primary Sedimentation tank (depth = 3.5m , radial = 5.8m)
3. First equalization tank (depth = 5.45m , length = 11.8m ,width = 21.7m)
4. Aeration tank (depth = 5.05m , length = 21.7m ,width = 10.8m)
5. Secondary sedimentation tank (depth = 3.5m , radial = 6.4m)
6. Second equalization tank (depth = 5.4m , length = 21.7m ,width = 11.45m)
7. Drying beds (depth = 70cm , length = 14m , width = 7m)

1.4 Problem of the study:

In Jordan the industrial wastewater disposed from industry represents a serious environmental problem due to the improper treatment techniques applied for organic–loaded wastewater. The variation in the quality of industrial wastewater make the treatment of different type of industrial wastewater using the same treatment system very difficult. The wastewater treatment plant in (AL-Hussein Bin AbdullahII industrial city) industrial city receives wastewater from different factories having different qualities, this has an adverse effect on the performance and efficiency of the existing treatment plant . Thus the treated wastewater need characterization and additional treatment to meet the required standard for its reuse.

1.5 Study area:-

The Jordan Industrial Estates Corporation (JIEC) was established in the year of 1980. It is a semi-governmental corporation that is responsible for developing industrial estates in order to enhance investment environment in Jordan and provide the industrial investors with the best infrastructure and service. JIEC currently owns five industrial estates located in different parts of the kingdom. Figure (1.1) show location of industrial cites.

1-King Abdullah II Industrial Estate/Amman (KAIE).
2-AL-Hassan Industrial Estate/Irbid (HAIE).
3- AL-Hussein Bin Abdullah II Industrial Estate/Karak (HUIE).
4- Aqaba international Industrial Estate/Aqaba (AIIE).
5- Maan Industrial Estate/Maan (MIE).

Al-Hussein Bin Abdullah II Industrial Estate (HUIE).

1. (HUIE) is located in Al-Karak Governorate, 118 Kilometers south of Amman the Capital, 11 Km east Al-Karak city.
2. A strategic location in the south, 20 Kilometers from Amman-Aqaba highway, which connects Amman the Capital with Aqaba city, and Jordan with the Gulf States and Egypt.
3. Inaugurated under the Patronage of His Majesty King Abdullah II Ibn Al-Hussein in October 2000.
4. Total area of (HUIE) is 186.6 ha, of which phase one was developed with an area of 57.8 ha.
5. Availability of various plots of serviced land and Standard Factory Buildings (SFBs).
6. There are 14 companies in operation at (HUIE), with invested capital of more than JD33.56 million employing 2532 workers.

1.6 Objectives of the study:-

The main objectives of the study are :-

1- Determine the quantity of wastewater produced from each factory Table(14) appendix .

2- Characterization of the quality of wastewater from each factory by determining the main quality parameters .

3- Identify the effect of mixing different types of industrial wastewater on the performance of the existing wastewater treatment plant.

4- Depending on the results of wastewater quality analysis, a pretreatment systems will be suggested and tested.

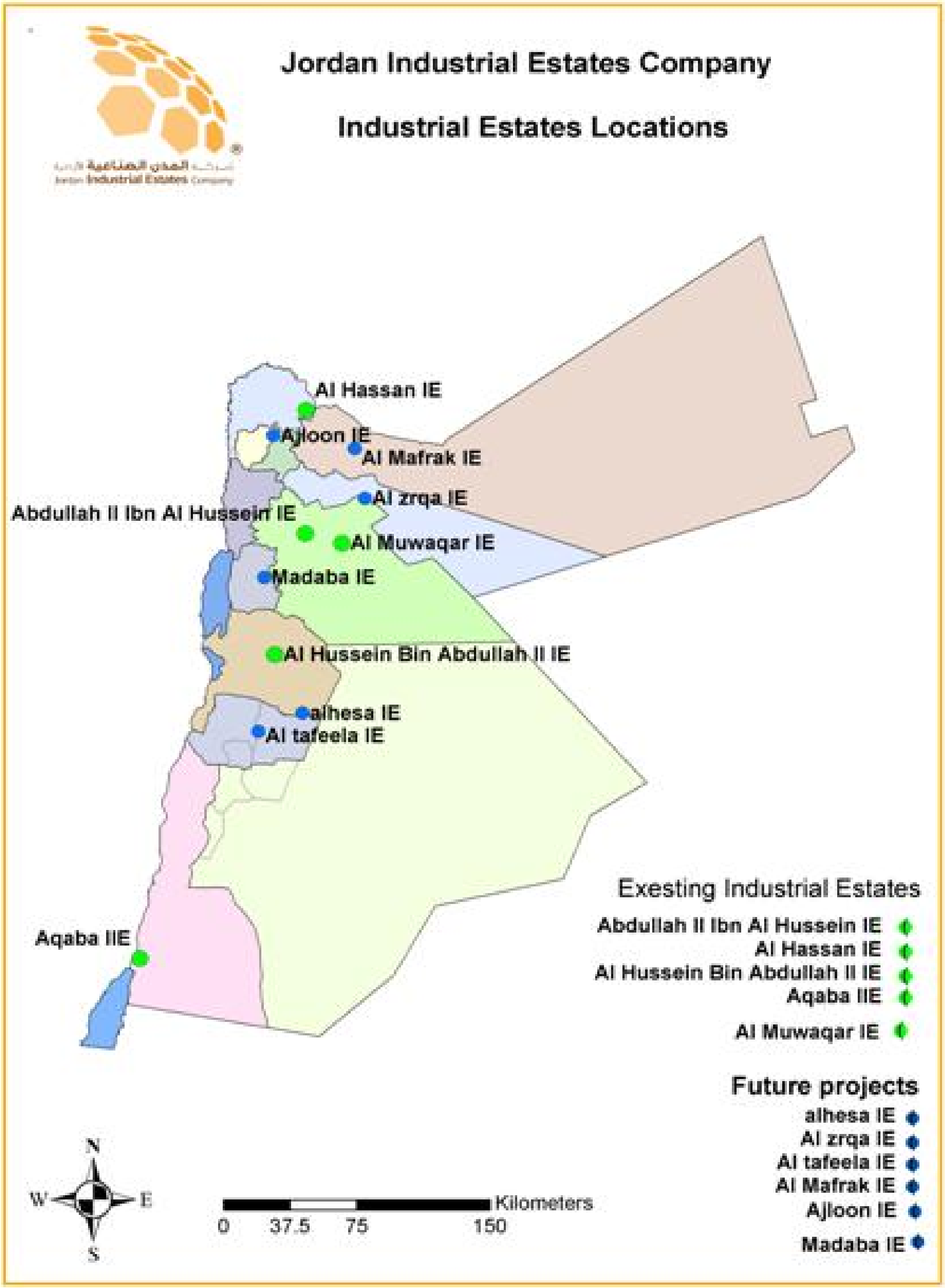

Figure (1.1)
Location map(JIEC.web site 2016)

Chabter Two
Industrial Wastewater

2.1 Background

Industrial wastewater varies in both quality and quantity. In general, industrial wastewaters may contain suspended, colloidal and dissolved (mineral and organic) solids. In addition, they may be either acidic or alkaline and may contain high or low concentrations of colored matter. These wastes may contain inert, organic or toxic materials. These wastes may be discharged into the sewer system provided they have no adverse effect on treatment efficiency or undesirable effects on the sewer system. It is cause necessary to pretreated the industrial waste water prior to disposal to the municipal system or it is necessary to a fully treatment when the wastes will be discharged directly to surface or ground waters.

2.2 Industrial Wastewater Characteristics

2.2.1 Physical characteristics

The principal physical characteristics of wastewater include solids content, color, odor and temperature.

Total Solids

The total solids in a wastewater consist of the insoluble or suspended solids and the soluble compounds dissolved in water. The suspended solids content is found by drying and weighing the residue removed by the filtering of the sample. When this residue is ignited the volatile solids are burned off. Volatile solids are presumed to be organic matter, although some organic matter will not burn and some inorganic salts break down at high temperatures. The organic matter consists mainly of proteins, carbohydrates and fats. Between 40 and 65 % of the solids in an average wastewater are suspended. Settle able solids, expressed as milliliters per liter, are those that can be removed by sedimentation. Usually about 60 % of the suspended solids in a municipal wastewater are settle able (Ron & George, 1998). Solids may be classified in another way as well: those that are volatilized at a high temperature (600 °C) and those that are not. The former are known as volatile solids, the latter as fixed solids. Usually, volatile solids are organic.

Color

Color is a qualitative characteristic that can be used to assess the general condition of wastewater. Wastewater that is light brown in color is less than 6hr old, while a light-to-medium grey color is characteristic of wastewaters that have undergone some degree of decomposition or that have been in the collection system for some time. Lastly, if the color is dark grey or black, the wastewater is typically septic, having undergone extensive bacterial decomposition under anaerobic conditions. The

blackening of wastewater is often due to the formation of various sulphides, particularly, ferrous sulphide. This results when hydrogen sulphide produced under anaerobic conditions combines with divalent metal, such as iron, which may be present. Color is measured by comparison with standards.

Odor

The determination of odor has become increasingly important, as the general public has become more concerned with the proper operation of wastewater treatment facilities. The odor of fresh wastewater is usually not offensive, but a variety of odorous compounds are released when wastewater is decomposed biologically under anaerobic conditions. The different unpleasant odors produced by certain industrial wastewater are presented in Table 2.1

Table 2.1

Unpleasant odors in some industries (Brault, 1991)

Industries	Origin of odors
Cement works, lime kilns	Acrolein, amines, mercaptans, dibutyl sulphide, H_2S, SO_2, etc.
Pharmaceutical industries	Fermentation produces
Food industries	Fermentation produces
Food industries (fish)	Amines, sulphides, mercaptans
Rubber industries	Sulphides, mercaptans
Textile industries	Phenolic compounds
Paper pulp industries	H_2S, SO_2
Organics compost	Ammonia, sulphur compounds

Temperature

The temperature of wastewater is commonly higher than that of the water supply because warm municipal water has been added. The measurement of temperature is important because most wastewater treatment schemes include biological processes that are temperature dependent. The temperature of wastewater will vary from season to season and also with geographic location. In cold regions the temperature will vary from about 7 to 18 °C, while in warmer regions the temperatures vary from 13 to 24 °C (Ron & George, 1998).

2.2.2 Chemical characteristics ·

Inorganic chemicals

The principal chemical tests include free ammonia, organic nitrogen, nitrites, nitrates, organic phosphorus and inorganic phosphorus. Nitrogen and phosphorus are important because these two nutrients are responsible for the growth of aquatic plants. Other tests, such as chloride, sulphate, pH and alkalinity, are performed to assess the suitability of

reusing treated wastewater and in controlling the various treatment processes (Rein, 2005).

Trace elements, which include some heavy metals, are not determined routinely, but trace elements may be a factor in the biological treatment of wastewater. All living organisms require varying amounts of some trace elements, such as iron, copper, zinc and cobalt, for proper growth. Heavy metals can also produce toxic effects; therefore, determination of the amounts of heavy metals is especially important where the further use of treated effluent or sludge is to be evaluated. Many of metals are also classified as priority pollutants such as arsenic, cadmium, chromium, mercury, etc.

Measurements of gases, such as hydrogen sulphide, oxygen, methane and carbon dioxide, are made to help the system to operate. The presence of hydrogen sulphide needs to be determined not only because it is an odorous and very toxic gas but also because it can affect the maintenance of long sewers on flat slopes, since it can cause corrosion. Measurements of dissolved oxygen are made in order to monitor and control aerobic biological treatment processes. Methane and carbon dioxide measurements are used in connection with the operation of anaerobic digesters.

Organic chemicals

Over the years, a number of different tests have been developed to determine the organic content of wastewaters. In general, the tests may be divided into those used to measure gross concentrations of organic matter greater than about 1 mg/l and those used to measure trace concentrations in the range of 10^{-12} to 10^{-3} mg/l. Laboratory methods commonly used today to measure gross amounts of organic matter (greater than 1 mg/l) in wastewater include (1) biochemical oxygen demand (BOD), (2) chemical oxygen demand (COD) and (3) total organic carbon (TOC). Trace organics in the range of 10^{-12} to 10^{-3} mg/l are determined using instrumental methods including gas mass spectroscopy and chromatography. Specific organic compounds are determined to assess the presence of priority pollutants (Metcalf & Eddy, 1991). The BOD, COD and TOC tests are gross measures of organic content and as such do not reflect the response of the wastewater to various types of biological treatment technologies. It is therefore desirable to divide the wastewater into several categories .

Volatile organic carbons (VOC)

Volatile organic compounds such as benzene, toluene, xylenes, trichloroethane, dichloromethane, and trichloroethylene, are common soil pollutants in industrialized and commercialized areas. One of the more common sources of these contaminants is leaking underground storage tanks. Improperly discarded solvents and landfills, built before the

introduction of current stringent regulations, are also significant sources of soil VOCs. Many of organic substances are classified as priority pollutants such as polychlorinated biphenyls (PCBs), polycyclic aromatic, acetaldehyde, formaldehyde, 1,3-butadiene, 1,2-dichloroethane, dichloromethane, hexachlorobenzene (HCB), etc,. In Table1 2-2, a list of typical inorganic and organic substances present in industrial effluents is presented.

Table 2.2

Substances present in industrial effluents (Bond & Straub, 1974)

Substances	**Present in Wastewaters from:**
Acetic acid	Acetate rayon, beet root manufact
Acids	Chem. manufact, mines, textiles manufact
Alkalies	Cotton and straw kiering, wool scouring
Ammonia	Gas and coke and chem. Manufacture
Arsenic	Sheep dipping
Cadmium	Plating
Chromium	Plating, chrome tanning, alum anodizing
Citric acid	Soft drinks and citrus fruit processing
Copper	Copper plating, copper pickling
Cyanides	Gas manufacture, plating, metal cleaning
Fats, oils, grease	Wool scouring, laundries, textile industry
Fluorides	Scrubbing of flue gases, glass etching
Formaldehyde	Synthetic resins and penicillin manufact
Free chlorine	Laundries, paper mills, textile bleaching
Hydrocarbons	Petrochemical and rubber factories
Free chlorine	Laundries, paper mills, textile bleaching
Mercaptans mills	Oil refining, pulp
Nickel	Plating
Nitro compounds	Explosives and chemical works
Organic acids	Distilleries and fermentation plants
Phenols	Gas and coke manufact., chem. Plants
Starch	Food processing, textile industries
Sugars	Dairies, breweries, sweet industry
Sulfides	Textile industry, tanneries, gas manufact.
Sulfites	Pulp processing, viscose film manufact.
Tannic acid	Tanning, sawmills
Tartaric acid	Dyeing, wine, leather, chem. manufacture
Zinc	Galvanizing zinc plating, rubber process.

2.3 Pollution load and concentration

In most industries, wastewater effluents result from the following water uses:

1. Sanitary wastewater (from washing, drinking, etc.);
2. Cooling (from disposing of excess heat to the environment);
3. Process wastewater (including both water used for making and washing products and for removal and transport of waste and by-products); and
4. Cleaning (including wastewater from cleaning and maintenance of industrial areas).

Excluding the large volumes of cooling water discharged by the electric power industry, the wastewater production from urban areas is about evenly divided between industrial and municipal sources. Therefore, the use of water by industry can significantly affect the water quality of receiving waters. The level of wastewater loading from industrial sources varies markedly with the water quality objectives enforced by the regulatory agencies. There are many possible in-plant changes, process modifications and water-saving measures through which industrial wastewater loads can be significantly reduced. Up to 90 % of recent wastewater reductions have been achieved by industries employing such methods as recirculation, operation modifications, effluent reuse or more efficient operation. As a rule, treatment of an industrial effluent is much more expensive without water-saving measures than the total cost of in-plant modifications and residual effluent treatment. Industrial wastewater effluents are usually highly variable, with quantity and quality variations brought about by discharges, operation start-ups and shutdowns, working-hour distribution and so on. A long-term detailed survey is usually necessary before a conclusion on the pollution impact from an industry can be reached (Wang & Howard 2004).

2.4 Industrial effluents

Whereas the nature domestic wastewater is relatively constant, the extreme diversity of industrial effluents calls for an individual investigation for each type of industry and often entails the use of specific treatment processes. Therefore, a thorough understanding of the production processes and the system organization is fundamental. There are four types of industrial effluents to be considered:

1- General manufacturing effluents: Most processes give rise to polluting effluents resulting from the contact of water with gases, liquids or solids. The effluents are either continuous or intermittent. They even might only be produced several months a year (campaigns in the agrifood-industry, two months for beet sugar production, for example). Usually if production is regular,

pollution flows are known. However, for industries working in specific campaigns (synthetic chemistry, pharmaceutical and parachemical industries), it is more difficult to analyse the effluents as they are always changing.

2- Specific effluents: Some effluents are likely to be separated either for specific treatment after which they are recovered, or to be kept in a storage tank ready to be reinjected at a weighted flow rate into the treatment line. Such as, pickling and electroplating baths; spent caustic soda.

3- General service effluents: These effluents may include wastewater (canteens, etc.), water used for heating (boiler blowdown; spent resin regenerants), etc.

4- Intermittent effluents: These must not be forgotten; they may occur from accidental leaks of Products during handling or storage, from floor wash water and from polluted water, of which storm water may also give rise to a hydraulic overload.

For the correct design of an industrial effluent treatment plant, the following parameters must be carefully established (I.W.T, 1999):

I. types of production, capacities and cycles, raw materials used,
II. composition of the make-up water used by the industrial plant,
III. possibility of separating effluents and/or recycling them,
IV. daily volume of effluents per type,
V. average and maximum hourly flows (duration and frequency by, type),
VI. average and maximum pollution flow (frequency and duration) per type of waste and for the specific type of pollution coming from the industry under consideration.

Since it can seriously, disturb the working of certain parts of the treatment facilities (glues, tars, fibers, oils, sands, etc.).

When a new factory is being designed, these parameters will be ascertained after analysis of the manufacturing processes and compared with data from existing factories. The amount and degree of pollution depend on the methods of manufacturing. For an example, in piggeries industry the method of cleaning will affect both the degree of pollution and water processing consumed (Wang & Howard 2004).

2.5 Effects of Industrial Wastewater

Some of the effects of industrial wastewater discharges on collection and treatment systems were discussed briefly before. This section will describe in more details how industrial wastewaters can affect the operation and performance of both the Industrial wastewater treatment system (IWTS) and the publicly owned treatment works

(POTW), and how direct discharges to the environment could affect receiving waters.

If an industrial waste stream is discharged to an IWTS which was not designed to handle it, the discharge may cause serious problems. It could interfere with the IWTS processes and/or pass through untreated to the POTW sewer. Similar effects may occur at the POTW and result in a violation of the discharge permit or prevent the reuse or recycle of water. The untreated industrial discharge could contaminate the industrial wastewater sludge or cause an air emission problem. It potentially could affect maintenance or production personnel working in or around the industrial sewer or treatment system through the generation of a toxic gas.

The seriousness of the effect will depend on the characteristics of the industrial waste streams, the size and design of the IWTS, and the standards for discharge, recycle or disposal of wastewater, sludge or air emissions. Accordingly, the effects of discharging the industrial effluent to the POTW or the environment will depend on the characteristics of the effluent, the type and size of the POTW system, and their standards for sludge and wastewater disposal or reuse. Waste characteristics such as temperature, pH, odor, toxicity, concentration, and flow must be evaluated to determine their acceptability to the IWTS. Similarly, understanding these characteristics of the IWTS effluent will also enable to predict the effect the effluent may have on the POTW system(Metcalf & Eddy, 1991) .

The effects of industrial waste discharges are not always negative; some beneficial effects also occur. For example, in a short POTW collection system, such as a small treatment system discharging to a trout stream, a continuous discharge of boiler blowdown from a large power plant can be cause for concern. High temperature discharges to sewers can accelerate (1) biological degradation, (2) slime growths, (3) odor production from anaerobic decomposition, and (4) corrosion of concrete pipe and metal sewer appurtenances. The high temperature wastewater can cause a bacterial population shift in the secondary treatment causing floating sludge and reduced BOD removal efficiency. This in turn would endanger the treatment plant's ability to meet its discharge permit limits. The high temperature wastewater may also cause the plant to exceed its temperature standards to the trout stream (I.W.T 2005).

On the other hand, the high temperature wastewater discharge from a power plant in a larger conveyance and treatment system located in a colder climate may, in fact, enhance the POTW secondary treatment processes removal efficiencies by keeping the wastewater temperature above 65 F (18 °C) all year. When evaluating an industrial wastestream, it is necessary to understand the specific characteristics of the waste and how they may affect each portion of the IWTS and in turn how the

effluent will affect the POTW's conveyance, treatment, disposal, and reuse facilities (I.W.T 2005).

2.5.1 Effects on the collection system

The IWTS collection system is designed and built to transport the individual and combined industrial wastestreams. If the collection system is not designed, built or operated correctly or if there is a spill, leak or accidental discharge of materials, the industrial discharges by themselves or in combination with other industrial wastewater can cause plugging, odors, erosion, corrosion, explosions, and numerous other problems. The good news, however, is that some industrial discharges contain substances that have a positive effect on the collection system, which may mitigate the effect of another industrial wastewater. The beneficial effects could include in-line neutralization. Large flows may produce scouring velocities in low-flow sewers or dilute a concentrated spill enough to produce a treatable waste within the capabilities of the IWTS (WBJ2003).

2.5.1.1 Hydraulic capacity problems

Hydraulic overload problems can occur if a large slug of wastewater or a continuous flow is discharged to the industrial sewer. The cause of a slug discharge may be a tank rupture or water line break. The cause of a continuous large flow may be a broken valve or one left open by mistake. The result in either case may be a sewer backup or pump station overflow. The smaller the capacity of the sewer or system, and the larger the contribution by the individual wastestream, the more likely it is this problem will occur. The solution may be to require flow restrictors on water valves or tank level switches to alarm high or low levels. If the condition regularly exists, for example, because of the introduction of a new manufacturing process that discharges a slug, equalization of the discharge may be necessary to store the effluent for off-peak hour discharge. A hydraulic overload condition may also occur if similar manufacturing processes discharge at the same time. For example, in a food processing industry there may be two sections of the plant that clean tanks, reactors, or cooking pots at virtually the same time. While the discharge from one manufacturing line may not cause a problem, the similar discharge schedule from another line will combine the wastewater flows and cause a hydraulic overload condition. Possible solutions include equalization of flow at the IWTS or at the manufacturing process and scheduling production and cleanup so that both lines are not cleaning at the same time(WBJ2003) .

2.5.1.2 Plugging

If the discharge from a manufacturing process contains large amounts of fibrous or stringy materials, heavy solids, adhesives, or grease, plugging of the sewer system may result. Plugging may occur just downstream of the discharge or in the pumping station. Fibrous or stringy materials get caught on rough surfaces and soon build up by entangling more solids. These types of materials can also wind themselves around pump impellers or shafts causing the pump to fail. If problems are occurring, it may be an indication of a problem with the manufacturing process or that the waste should have been pretreated prior to discharge. Review the manufacturing process to determine if changes in the process or disposal of wastes are required or if the sewer needs to be enlarged to accommodate the materials. Heavy solids such as sand, ceramic or porcelain solids, or grindings can build up in a sewer or pump station wet well and reduce its hydraulic capacity. Solids that are not removed by pretreatment at the process may be discharged during peak wastewater flows during the day and may settle in pump station wet wells or oversized sewers downstream of the actual point of discharge when the flow subsides. The solids then have an opportunity to compact and may not become resuspended when the flow in the sewer returns to its peak flow. This cycle of transporting the solids to a section of the collection system to settle, build up, and compact will eventually cause a restriction. A complete blockage may also occur if large objects are released to the sewer. Rags, tools, rejected food products, and discarded by-products may accidentally be released to the sewer due to operator carelessness or equipment malfunction. Because of their size, they can easily become wedged or entangled with other waste material and completely block the sewer or lift station pump(WBJ2003) .

2.5.1.3 Odors

Examples of industrial discharges that can be odorous are those from petroleum refining, petrochemical manufacturing, and food processing. Generally, the odors are produced from a compound containing sulfur, such as mercaptants or hydrogen sulfide. These compounds in air are detectable in the parts-per-billion range (by volume) and can cause complaints from residents and other industries. While the problem is airborne, the actual cause originates in the industrial discharge. It is even more common to find this problem in the discharge to the POTW system. The first solution may be to change the manufacturing process. Sour water, which is wastewater containing high concentrations of sulfide from the petroleum refining industry, can be stripped with steam and reduced to elemental sulfur using the Klaus process. This process and other similar recovery processes have reduced

the odor pollution problem while producing a saleable by-product (sulfur). Another solution may be to oxidize the offending components prior to discharge using air, hydrogen peroxide, or chlorine; or not discharge them at all. The wastewater produced during the etherification reaction to make polyester is very odiferous. Because of the quantity of organics in the wastes, it is practical to incinerate the wastes at no net fuel expense and solve the odor problem.

Industrial discharges of sulfide can result in toxic and corrosive conditions. If there is biodegradable material, a source of bacteria and a source of sulfide or sulfate in the industrial wastestreams, hydrogen sulfide gas may be produced under anaerobic conditions in the sewer. Bacteria reduce the inorganic sulfate to sulfide when there is insufficient oxygen in the wastewater (less than 0.1 mg/L), thus producing hydrogen sulfide gas. The sulfide is subsequently oxidized to sulfate by other bacteria under aerobic conditions, producing sulfuric acid which is extremely corrosive to the crown (upper section) of sewer pipes (I.W.T, 2005).

Besides an odor problem, hydrogen sulfide also presents a safety (toxic gas) problem to sewer maintenance personnel and the IWTS operator or, if discharged to the sanitary sewer, the POTW collection system and treatment plant operators. Hydrogen sulfide when dissolved in the wastewater will also produce sulfurous and sulfuric acid, very corrosive materials that attack uncoated metal and concrete surfaces. The anaerobic reduction usually requires a long detention time and an active biological population. Sources of sulfide and sulfate should be identified and recovered or treated prior to discharge. Some suggested solutions to this problem are: require oxygenation and/or chlorination prior to discharge; aerate the wastewater in the collection system; periodically remove the slime layer of anaerobic growth in the system with a slug loading of alkali or chlorine; or periodically clean the sewer with a highvelocity cleaner or a pig (a sewer-cleaning device). Industrial discharges to the POTW containing high concentrations of sulfide are normally restricted. Limitations of 5 mg/L of total sulfide and 0.5 mg/L of dissolved sulfide are used (I.W.T, 2005).

2.5.1.4 pH Problems

The pH of an industrial discharge or the amount of acids and alkalies discharged to an industrial sewer are normally taken into account during design. While older plants in the petroleum, primary metals, and chemical industries have sewers constructed from less corrosion-resistant materials, many of the modern facilities use plastics, fiberglass or other resin material for the industrial wastewater piping and sewer systems. Difficulties can arise when the manufacturing process changes or new

chemicals are used that are not compatible with the existing sewer system. For example, fiberglass piping is an acceptable material of construction for sulfuric acid, but if the plating operation adds a process using hydrofluoric acid, the fiberglass may be severely damaged.

The industrial collection system may be designed to handle strong acids or alkalies, but may not be designed to withstand the heat of solution or reaction. For example, when a concentrated solution of sodium hydroxide (such as a spent alkaline cleaner) is discharged to the sewer, there could be a large temperature rise due to the heat of solution. If there is only a small quantity of stagnant wastewater in the sewer or pump station, the heat of solution may exceed 104 degrees Fahrenheit (40 °C), the deformation temperature of PVC (I.W.T, 2005). A spill of liquid chlorine can cause a temperature rise sufficient to produce steam resulting in a very toxic gas. Liquid chlorine can also damage plastics directly. Acids will corrode concrete and cast iron sewers, concrete wet wells and tanks, the internal steel equipment in the primary and secondary clarifiers, trickling filters, aerators, and pumps. Mineral acids such as sulfuric, nitric, hydrochloric, and phosphoric acids are used extensively to clean base metals in the metal finishing industries. The fertilizer, iron and steel, mining, and petroleum industries also use vast quantities of these strong acids(I.W.T, 2005).

2.5.1.5 Flammables

The discharge of flammables is potentially the most damaging industrial discharge to the collection system. Gasoline, aviation fuel, and hexane used in soybean extraction have been responsible for explosions in sewers causing losses of millions of dollars for sewers and businesses, the loss of service to hundreds of people, and loss of life. Industries producing, distributing, and using fuels and solvents are regulated and monitored to prevent discharge of these materials. Generally, fuels and solvents are only slightly soluble in water and have a specific gravity less than water. When accidentally discharged to the sewer, they will float and accumulate in slow-moving sewers and in pump station wet wells.

Any source of ignition such as an arc from tripping a breaker or a motor, or a spark created while removing a manhole cover with a pick can cause a fire or explosion.

The discharge of flammables to the POTW sewer is dangerous for the same reasons noted above. If the concentration of flammables is high enough, an explosive atmosphere can develop, especially if the secondary treatment process is covered or uses pure oxygen. Any hydrocarbon may cause a flammable hazard in a pure oxygen activated sludge system. However, these systems are usually equipped with sensors and purge systems to prevent flammable and explosive conditions from developing.

2.5.1.6 Temperature

Heated industrial wastewaters originate from controlling manufacturing process reactions and as a by-product from utilities production of energy. In manufacturing processes, heat is often used to increase the rate of reaction and thus creates a heated product or waste which must be cooled. Water or steam is often used directly or indirectly (by means of heat exchangers) to heat or cool the product or by-product and to transport it to the next processing step. The metal finishing industry uses steam to heat process solutions. Accumulated solids must be removed from boilers to prevent plugging of the boiler tubes and steam lines. The discharge is called boiler blowdown. In cooling systems, single-pass cooling water and cooling tower blowdown can also contribute a heat load to the industrial and POTW sewers. Heated industrial discharges can cause many problems in the IWTS collection and treatment systems including evolution of gases and odors, overheating of pump and rotating equipment bearings, shifts in the population of microorganisms used in biological treatment of industrial wastewater, or even sterilization (killing of all organisms) in the wastewater(I.W.T, 2005) .

Plastic pipe (PVC) has temperature limitations of around (40 °C) and can fail if used for hot water transport. In the POTW sewer laterals, the O-rings may not be designed to withstand a constant high temperature; if they fail, exfiltration or infiltration of the collection system may occur. The same problems identified in the industrial sewer can also occur in the POTW collection and treatment system. In addition, if the POTW is discharging to a stream or lake with a temperature limit (for example, a trout stream), then a high temperature discharge by an industrial source can cause the POTW to violate its permit limit (I.W.T, 2005).

2.5.2 Effects on the treatment system

Industrial waste discharges damage treatment plant equipment in many of the same ways they damage the collection system. High volume discharges can exceed the pumping capacities; plugging of mechanical equipment such as bar screens or pumps can occur from a high solids discharge; acids and alkalis will corrode metal parts eventually causing failure; and flammables in the treatment plant are an explosive problem that can cause almost instantaneous damage. The added potential problem with industrial discharges is their effect on the treatment processes, including blinding of filters with oil; plugging microfiltration, nanofiltration or reverse osmosis membranes; interfering with recovery processes by contaminating the by-product; and overloading or upsetting

the aerobic and anaerobic biological treatment processes (Degremont 1979).

2.5.2.1 Hydraulic overload

Unit processes such as neutralization, sedimentation, filtration and biological treatment operate best at a constant flow and constant loading conditions. Large changes in the volume of flow or rapid changes in loading will decrease the efficiency of these processes. Hydraulic surges from an industrial process or utility discharge can cause these rapid variations. To compensate, the treatment plant must make a series of changes in their plant operating conditions, such as changing the sludge removal rate, increasing the blower output, or increasing the chemical addition rate. The alternative is to suffer possible effluent limit violations. Equalization of the flow at the source or installed as a part of the IWTS provides the best means of controlling hydraulic surges and operating the treatment processes at a constant or near-constant flow(WBJ2003) .

2.5.2.2 Interference

Environmental Protection Agency (EPA) defines interference as a discharge which, alone or in conjunction with discharges from other sources, inhibits or disrupts the POTW, its treatment processes or operations, its sludge processes, use or disposal, and is a cause of preventing the lawful use or disposal of sludge. This definition of interference applies equally well to discharges by industrial processes to the IWTS. By working closely with the manufacturing and utility operators, the IWTS operator can identify potential interference problems before they cause a discharge violation. Good communication between the operators in the manufacturing facility and the IWTS operator is the most reliable way to identify changes, whether sudden or gradual, in the operation of the plant or quality of the effluent. Discharge of untreated wastes or even large quantities of treated wastes can cause interference with the POTW treatment processes. Table (1-3) illustrates examples of how industrial discharges may cause potential interference with the POTW's treatment processes (Degremont 1979).

2.5.2.3 Influent variability

Measurements of wastewater flow, pH, temperature, and conductivity are used to detect changes in the influent to the IWTS or POTW. As with hydraulic surges, variability in the chemical composition of the influent wastewater can cause upsets in the treatment processes. The larger the difference between the existing influent composition and the contribution from the industrial discharge, the larger the potential for problems. A change of one pH unit represents a tenfold change in the

concentration of acid in the influent. Chemical reactions, precipitation, settle ability and filterability are greatly changed by the pH of the wastewater. For biological treatment systems, both aerobic and anaerobic treatment are inhibited by rapid changes in environmental conditions. Operation outside of the pH range of 7.0 to 8.5 can be toxic to bacteria; however, if the change is gradual the microorganisms can become acclimated to pH levels slightly beyond this range. Changes in conductivity or ORP (oxidation-reduction potential) normally represent increases or decreases in soluble salts, cyanide or metals. Inhibition or interference can range from overloading the chemical processes with the mass of metals or cyanide requiring treatment to inhibiting the biological reactions. Changes in soluble salt concentrations alter the rate of oxygen transfer through bacterial cell walls and therefore affect the health and performance of the microorganisms(Degremont 1979).

2.5.3 Effects on the POTW

Effects of an industrial discharge on the POTW collection, treatment and disposal system parallel those of a manufacturing process waste on the IWTS. There are problems with each component of the system. The Pretreatment Regulations were established to remove toxic pollutants at the source and to protect the POTW's collection, treatment and disposal systems and the environment.

The effects of an industrial discharge on the POTW will always depend on the characteristics and flexibility of the system, the level of skill possessed by the POTW inspectors, laboratory analysts, and POTW operators, and the amount and type of industrial flow. Factors such as the size and length of the sewer system also influence how an industrial discharge will affect the POTW collection system. In general, the larger the system, the less effect a single industrial discharge will have on the POTW regardless of whether the industrial discharge is a slug loading or a constant discharge. Dilution and equalization of the industrial discharge occur naturally in the larger collection systems, thereby reducing the effect on the POTW facilities. As the complexity of the POTW treatment system increases from only primary treatment to tertiary treatment, the effect of an industrial discharge also increases. The higher degrees of treatment are more sensitive to upset from industrial discharges. Secondary and tertiary biological processes such as activated sludge, nitrification, denitrification, and anaerobic digestion can be upset by a toxic "overdose" of heavy metals. Tertiary physical-chemical processes such as sand filtration can be rendered useless by a passthrough of oil or a carryover of gelatinous (jelly-like) bacteria from an upset biological process. If the configuration of the treatment system can be easily changed, the effect of an industrial discharge may be lessened. Changing

the recycle ratio on a trickling filter or altering the biomass concentration in an activated sludge system could prevent pass-through of no compatible pollutants or air strip volatile organic compounds. Changing a two-unit process from parallel operation to series operation may help to remove high loadings of compatible pollutants. The disposal of the POTW effluent and sludge are also affected by industrial discharges. The effluent discharge requirements are more stringent for water reuse than for discharge to receiving waters. POTW sludge being used as a component in compost for resale must meet stricter quality requirements than sludge being land filled. Toxic components of industrial discharges may limit the recycle and reuse options if the POTW is not properly protected from slug loadings or if contaminated concentrations reach a level that may pass through and be discharged in the effluent or sludge. When certain metals reach high enough concentrations in the sludge, then the sludge must be handled as a hazardous waste (Wang & Howard 2004).

2.6 Previous studies

Nassar & Haimour (1990). Investigated water conservation for Jordan paper and cardboard factories Analyzed the wastewater of the Jordan paper and cardboard mill effluent, and found that it contains (3000mg/l) suspended solids with a pollution load of (1400mg/l) COD and (500mg/l) BOD5 . They suggested an internal treatment cycle by closing the white water system which can be accomplished by installing a floatation save all (fiber recovery unit). In this arrangement, 90% of fresh water used may be saved , (80-90)% of the fiber loss is reduced, the production rate is increased and consequently the pollution load is decreased.

Naser (1992). investigated Industrial wastewater treatment by floatation. A jar-test dissolved floatation apparatus was built and the floatation behavior of three wastewater samples from local industries, namely two from a paper mill and one from a food processing factory were studied.

The main physical parameters investigated in order to characterize the floatation behavior are the air/solid ratio (A/S) and the pressurizing time of wastewater. Floatation with three different flow modes, namely recycle flow, spilt flow and full flow floatation were used, and the effect of the recycle ratio or the spilt ratio were also investigated. The result show that pressurizing time does not have significant effect on the effluent total suspended solid. A pressurizing time of 1 minute, recycle ratio of 1:1 and split ratio of 1:1 were selected for further experiments.

The value of A/S varied according to the employed flow mode where split flow mode exhibited the least A/S value, thus it was chosen to test

the effect of chemical additives on the effluent total suspended solids (TSS).

The lowest effluent (TSS) was about (255mg/l), obtained for high-solid paper mill effluent.

The percent recovery of (TSS) reached as high as (89%) for high-solid paper mill effluent, while it is only about (30%) for the food processing effluent.

The maximum BOD5 and COD percent reductions were obtained using split flow mode for paper mill effluent samples and ranged from (68-74%).

Two chemical were tested for their effect on the floatation behavior, namely aluminum sulfate (a collecting agent) and 2-octanol (a frothing agent). The optimum doses of collected were (500 and 350mg/l) for high-solid paper mill wastewater and food processing wastewater respectively. The optimum frothier does for food processing wastewater was (2000mg/l), while the effluent (TSS) of high-solid paper mill wastewater was not affected by the frothier addition.

Jiries (2001). Chemical evaluation of treated sewage effluents in karak province and its suitability for irrigation purpose The evaluation of those effluents was made on the basis of combination of electric conductivity (EC), sodium adsorption ratio (SAR), soluble sodium percent (SSP), boron concentration and heavy metal content. The results showed that a slightly high boron concentration was detected in some samples at Karak wastewater treatment plants, while higher heavy metals content was found at Mutah university wastewater treatment plant which was attributed to the laboratory experiments done in the scientific faculties. However the quality of the treated wastewater of both site met the criteria and standards for the use of effluents in irrigation and agriculture.

Dakiky et al.,2002.Investigated the selective adsorption of chromium(VI) in industrial wastewater using low-cost abundantly available adsorbents the removal of poisonous Cr (VI) from industrial wastewater by different low-cost abundant adsorbents was investigated. Wool, olive cake, sawdust, pine needles, almond shells, cactus leaves and charcoal were used at different adsorbent/metal ion ratios. The influence of pH, contact time, metal concentration, adsorbent nature and concentration on the selectivity and sensitivity of the removal process was investigated. The adsorption process was found to follow a first-order rate mechanism and the rate constant was evaluated at 30°C. In the case of wool, the rate constant was the highest (39.6×10^{-3} min^{-1}) and the cactus leaves gave the lowest value (6.8×10^{-3} min^{-1}). Langmuir and Freundlich isotherms were applicable to the adsorption process and their constants were evaluated. The thermodynamic equilibrium constant and the Gibbs free energy were calculated for each system. The ΔG^{o} for the absorption

by wool (−2.26 kJ mol^{-1}) and that for the cactus leaves (2.8 kJ mol^{-1}) supported the findings that wool was the best among the selected adsorbents for the selective removal of Cr(VI) at pH 2 and an adsorbent concentration of 16 g l^{-1} at 30°C, for which the removal was 81% out of 100 ppm Cr(VI) after 2 h of stirring. A comparison between a simulated sample containing 100 ppm Cr(VI) and a true wastewater sample containing 100 ppm Cr(VI), 19 ppm Al, 30 ppm Mg, 49 ppm Ca, and 10 ppm B, showed that the adsorption process is satisfactory and selective for Cr(VI).

Dabrowski et al.,2004.Investigated Selective removal of the heavy metal ions from waters and industrial wastewaters by ion-exchange method. By ion exchange undesirable ions are replaced by others which don't contribute to contamination of the environment. The method is technologically simple and enables efficient removal of even traces of impurities from solutions. Examples of selective removal of heavy metal ions by ion-exchange are presented. They include removal of Pb(II), Hg(II), Cd(II), Ni(II), V(IV,V), Cr(III,VI), Cu(II) and Zn(II) from water and industrial wastewaters by means various modern types of ion exchangers.

Saeed (2004).Investigated Industrial wastewater Treatment – Fat and Detergents ,This thesis present the investigation of the type and efficiency of the existing on-situ industrial wastewater treatment plant at yemen company for Ghee and soap Industry. The purpose is identifying the major pollutants in the Ghee, soap and synthetic detergents wastewater. The investigations were carried out in order to inspect the performance of the industrial wastewater treatment plant and the difficulties faced in operating it . A modified treatment plant and a suggest plant were recommended in order to improve it's efficiency, and to reduce the negative environmental problems .

Nasr et al., 2004. Chemical industry wastewater treatment. treatment of chemical industrial wastewater from building and construction chemicals factory and plastic shoes manufacturing factory was investigated. The two factories discharge their wastewater into the public sewerage network. The results showed the wastewater discharged from the building and construction chemicals factory was highly BOD were (2912) mg/l . phenol concentration up to (0.3 mg/l) was detected. Chemical treatment using lime aided with ferric chloride proved to be effective and produced an effluent characteristics in compliance with Egyptian permissible limits. With respect to the other factory , industrial wastewater was mixed with domestic wastewater in order to lower the organic load . The COD, BOD value after mixing reached (5239) and (2615) mg/l . The average concentration of phenol was (0.5)mg/l .Biological treatment using activated sludge or rotating biological

contactor (RBC) proved to be an effective treatment system in terms of producing an effluent characteristic within the permissible limits set by the law. Therefore, the characteristics of chemical industrial wastewater determine which treatment system to utilize. Based on laboratory results engineering design of each treatment system was developed and cost estimate prepared.

Aessa 2005.investigated decolaurization of wastewater on textile industry by photocatalytic degradation process using Tio2 in aqueous suspension, the objective of this work is to study remove color textile wastewater like (methyl orange, azo carmine B, coomassie brilliant blue G250,Tartrazine,calcon,…) remove by photo catalytic degradation process by using TiO_2 , the kinetics of reaction have been studied and were found to be zero or first order with respect to the dye. It was compared with the adsorption properties . we have studied the chemical coagulation for the same dyes. It was compared with the photo catalytic degradation and we found that the last one is more effective.

AL-Sghireen 2006.investigated low cost treatment of textile wastewater generated by the blue Jeans industry at Al-Hassan Industrial Estate, Ramtha – Jordan In this study it used natural materials to treatment industrial wastewater effluent from textile jeans factory in AL-Hassan Industrial Estate , it showed from this study there are chemical and physical differences in industrial wastewater depending on the type of source. It has been identified efficiency for different materials by measuring the turbidity, PH , BOD5 , color , total suspended solid. The materials used in the treatment (Azraq bentonite , Jordanian clay , commercial bentonite , Jordanian zeolitic tuff , lime Cao , Activated carbon).

AL-Reafay 2007. Investigated hydrochemistry of industrial raw water and treated of some Industries in AL-Mafraq-Jordan the aim of the study is to identify the concentration of heavy metals and its effect on the industrial water in the study area (Al-mafraq governorate) which is considered as a semi-arid region with 200millilitres annual rainfall , Heavy metals concentration (Cr, Cu, Ni, As, Cd, Co, Mn, Zn, Fe) were tasted in the samples by using Absorption spectroscopy ,

The highest concentration of these heavy metals that produced from (soap and oil factory, cleanings factory, food factory) .Recommendations

1- continuous monitoring the wastewater effluent from all factories.
2- the treated wastewater effluent from factories.
3- enforcement of laws on violators of the regulations and standards.
4- Work on finding alternative materials for heavy metals in any industry so that they are less harmful.

AL-Bashabsheh 2007. investigated wastewater and sludge quality in industrial cities, Jordan the objective of this study is to show the quality of reclaimed wastewater and sewage sludge produced from the major industrial cities king Abdullah II Industrial estate (KAIE), AL-Hassan Industrial city (HAIE) and AL-Hussein Bin Abdullah II Industrial city (HVIE) in Jordan was evaluated in term of physiochemical characteristics, nutrient, major ionic composition and heavy metals content. The study showed that the levels of heavy metals, anions and cations for effluent treated water were almost higher for (KAIE) than those found for HAIE and HVIE. The (Cl-) and (Na+) concentration level in wastewater effluent at KAIE and HVIE which was higher than Jordanian standard which might be due to food industries.

Recommendations

1) the treated wastewater effluent from all sampling sites should be used for irrigation on site as they were located in .
2) continuous monitoring of ground water and soil properties must be done to detect any impact of the use of effluent wastewater.
3) Further investigation on wastewater and sewage sludge quality shoud be encourage indeed especially regarding organic pollutants.

Gharaibah 2007,investigated Adsorption of phenol and methylene blue from industrial wastewater using modified pottery: kinetic, thermodynamic and isotherm studies**.**In this study the removal of phenol and methylene blue from aqueous solution by adsorption was investigated. For this purpose high grade of phenol and methyline blue were used as solution sample. These samples were treated by using dilute nitric acid, then analyzed chemically by XRF spectroscopy equipment, also the XRD patterns were obtained. The research focused on the isotherm of single absorbate solution it was found that the adsorption increased with increasing temperature and concentration.

AL-Absi et al.,2008.investigated mineral content of three olive cultivars irrigated with treated industrial wastewater, this research work aimed at evaluating the potential utilization of saline treated wastewater from Al-Husseun Bin Abdullah II industrial Estate (HUIE), as a source of water and its effect on vegetative growth, leaf proline and chlorophyll contents and oil quality of three olive cultivars under partially controlled conditions and two cultivars under field conditions during a two-years period. the reuse of saline treated industrial wastewater generated by textile firms mixed with municipal domestic effluent for irrigation was used to assess its effect on the mineral content of three olive cultivars under greenhouse and field conditions during two complete vegetative cycles. Chemical analysis of the treated wastewater indicated that the element concentrations fall within the permissible range of irrigation water used for plants. However , little impermissible accumulation of (Na)

and (Mg) higher than the recommended maximum concentration was observed. The result of the greenhouse experiment showed that leaf (N,Cu,Mn,Fe,Pb,and Na) contents increased with increasing salinity of the treated wastewater. This increase was accompanied with a decrease in (K and Mg) contents. leaf Ca and Cl concentrations were not considerably affected. Ion analysis in roots indicated that the contents of P,Na,Cl,Mn,and Pb increased while K decreased as treated wastewater salinity increased.

Zeng et. al., 2011 had operated a lab-scale anaerobic–anoxic–aerobic (A2O) to investigate denitrifying phosphorus removal and nitration–denitritation from domestic wastewater, especially regarding the impact of nitrite accumulation caused by nitration on phosphorus removal. The results showed that mean total nitrogen (TN) removal was only about 47% and phosphorus removal was almost zero without thepre-anoxic zone and additional carbon source. Contrastively, with configuration of pre-anoxic zone, TN and phosphorus removal was increased to 75% and 98%, respectively, as well as denitrifying phosphorus removal of 66–91% occurred in the anoxic zone. Nitration–denitritation was achieved through a combination of short aerobic actual hydraulic retention time and low dissolved oxygen levels (0.3–0.5 mg/L);however, phosphorus removal deteriorated with increase of nitrite accumulation rates. The free nitrous acid (FNA) concentration of 0.002–0.003mg HNO_2–N/L in the aerobic zone inhibited phosphorus uptake,which was major cause of phosphorus removal deterioration. Through supplying the carbon sources to enhance denitrification and anaerobic phosphorus release, nitrite and FNA concentrations in the aerobic zone were reduced, and phosphorus removal was improved. Compared with nitrification–denitrification,nitration–denitritation reduced the carbon requirement by 30% and performed biological nutrients removal well with mean TN and phosphorus removal of 85% and 96%, respectively.

Khudhair ,2012 Removal of Textile Dye from Aqueous Media by Advanced Oxidation processes .was investigated for the Advanced Oxidation Process (AOPs) considered herein were the homogeneous processes including photolysis (UV), (H_2O_2 alone), (UV/H_2O_2), and heterogeneous photocatalytic processes which are being modified processes (use Fe^0 instead of using ferrous salts) including Fenton (H_2O_2/Fe^0) and photo Fenton (UV/H_2O_2/Fe^0).

The removal efficiency for the process UV/ H_2O_2 at the optimal conditions and dosage (H_2O_2 = 25mg/L, pH=3, temperature =20^oC) for 50mg/L dye concentration was found to be 80.633% , 97.07 , 99.43% at time 60 min, 120 min,180 min respectively and the removal efficiency for the process UV/ H_2O_2 /Fe^0 at optimal conditions and dosage (H_2O_2 = 25mg/L, Fe^0=5mg/L, pH=3, temperature=20^oC) for 50mg/L dye

concentration was found to be 95.44%, 96.7% at time 60min ,70 min respectively.

The augmentation of UV/ H_2O_2 process by adding Fe enhance the performance of AOPs with removal efficiency by 14.81% which is considered as satisfactory improvement.

Two extra experiments of AOPs were done without aluminum foil, to investigate the performance of UV/H_2O_2 and photo Fenton processes without aluminum foil. The removal efficiency decreased from 80.63 %to 73.1346 % for time 60min whereas for time 180min it decreased from 99.43 % to 97.39%. While for photo Fenton, the removal efficiency decreased from 95.44% to 94.73% at time 60 min whereas it decreased from 96.7 % to 95.92% for time 70 min.

Two sources of Zero-valent iron (ZVI) iron powder and iron filings from workshop were used due to its availability and cheapness. They gave good removal efficiency. The comparison of both sources was 95.47% - 96.698 % at time 70min for iron filings and iron powder respectively.

Sun light was also investigated instead of UV lamp. It was involved two processes UV/H_2O_2 and photo Fenton and the removal efficiency was 6.08%, 94.333% for UV/H_2O_2 and photo Fenton respectively.

COD reduction was also studied for two processes UV/H_2O_2 and photo Fenton and gives 62.5% and 88.39% respectively.

The comparison of the removal efficiencies selected at 60 min reaction time were (1.76, 6.08, 73.538, 80.63, 94.33, 95.439) % for photolysis (UV), sun light/H_2O_2, Fenton, UV/H_2O_2, sun light/Fenton, UV/Fenton respectively.

In photo Fenton system, the removal of reactive yellow and reactive blue was carried out and gave good removal efficiency when compared to removing reactive red dye. It was clear that the red dye, which represents, the values of removal efficiency was the most critical compared with other used dyes

Zeb et al.,2013. Combined industrial wastewater treatment in anaerobic bioreactor posttreated in constructed wetland. they investigated for the post treatment of anaerobic bioreactor (ABR) treating combined industrial wastewater. Different dilutions of combined industrial wastewater (20,40,60,and 80) and original wastewater were fed into the ABR and then post treated by the laboratory scale constructed wetland(CW). The respective removal efficiencies of COD,BOD,TSS,nitrates, and ammonia were 80%,78-82%,91.7%,88-92%, and 100% for original industrial wastewater treated in ABR. ABR was efficient in the removal of Ni,Pb, and Cd with removal efficiencies in the order of Cd (2.7%)>Ni (79%)>Pb(85%). Posttreatment of the ABR treated effluent was carried out in lab scale CW containing A.donax L. CW was effective in removal of COD and various heavy metals present in ABR

effluents. The posttreatment in CW resulted in reducing the metal concentrations to 1.95mg/l,0mg/l, and 0.004mg/l. for Ni,Pb, and Cd which were within the permissible water quality standards for industrial effluents. The treatment strategy was effective and sustainable for the treatment of combined industrial wastewater.

Kamika et al.,2013. Assessing the resistance and bioremediation ability of selected bacterial and protozoan species to heavy metals in metal-rich industrial wastewater**.** this study assessed the resistance to and bioremediation of heavy metals by selected protozoan and bacterial species in highly polluted industrial wastewater. Specific variable (i.e. chemical oxygen demand , PH , dissolved oxygen) and the growth/die-off –rates of test organisms were measured using standard methods. Heavy metal removals were determined in biomass and supernatant by the inductively couple plasma optical emission spectrometer. A parallel experiment was performed with dead microbial cells to assess the biosorption ability of test isolates. The results revealed that the industrial wastewater samples were highly polluted with heavy metal concentration exceeding by far the maximum limits (in mg/l) of (0.05-Co,0.2-Ni,0.1-Mn,0.1-V,0.01-Pb,0.01-Cu,0.1-Zn and 0.005-Cd,) prescribed by the UN-FAO. Industrial wastewater had no major effect on pseudomonas putida, Bacillus licheniformis and peranema sp. (growth rates up to 1.81,1.45 and 1.43 d-1,respectively) compared to other test isolates. This was also revealed with significant COD increases ($p<0.05$) in culture media inoculated with living bacterial isolates (over 100%) compared to protozoan isolates (up to 24% increase). Living pseudomonas putida demonstrated the highest removal rates of heavy metals (Co-71%,Ni-51%,Mn-45%,V-83%,Pb-96%,Ti-100% and Cu-49%) followed by Bacillus licheniformis (Al-23% and Zn-53%) and peranema sp. (Cd-42%). None of the dead cells were able to remove more than 25% of the heavy metals. Bacterial isolates contained the genes copC,chrB,cnrA3 and nccA encoding the resistance to Cu,Cr, Co-Ni and Cd-Ni-Co, respectively. Protozoan isolates contained only the genes encoding Cu and Cr resistance (copC and chrB genes). Peranema sp. Was the only protozoan isolate which had an additional resistant gene cnrA3 encoding Co-Ni resistance. Significant differences ($p<0.05$) observed between dead and living microbial cells for metal-removal and the presence of certain metal resistant genes indicated that the selected microbial isolates used both passive (biosorptive) and active (bioaccumulation) mechanisms to remove heavy metals from industrial wastewater. This study advocates the use of peranema sp. As a potential candidate for the bioremediation of heavy metals in wastewater treatment, in addition to pseudomonas putida and Bacillus licheniformis.

Mirbagheri et al.,2015.Performance evaluation and modeling of a submerged membrane bioreactor treating combined municipal and industrial wastewater using radial basis function artificial neural networks**.**the current research was an effort to evaluate performance of submerged membrane and industrial wastewater and to simulate effluent quality parameters of the submerged membrane bioreactor (SMBR) using a radial basis function artificial neural network (RBFANN). The results show that the treatment efficiencies increase and hydraulic retention time (HRT) decreases for combined wastewater compared with municipal and industrial wastewater. The BOD,COD,NH4-N and total phosphorous (TP) removal efficiencies for combined wastewater at HRT of 7hours were 96.9% , 96% , 96.7% and 92% , respectively. As desirable criteria for treating wastewater , the TBOD/TP ratio increased the BOD and COD concentrations decreased to 700 and 1000mg/l respectively and the BOD/COD ratio was about 0.5 for combined wastewater. The training procedures of the RBFANN models were successful for all predicted components. The train and test models showed an almost perfect match between the experimental and predicted values of effluent BOD, COD,NH4-N and TP. The coefficient of determination (R2) values were higher than 0.98 and root mean squared error (RMSE) values did not exceed 7% for train and test models.

Prieto et al.,2015. An environmental management of industrial solution for the treatment and reuse of mussel wastewaters. In the North-West of Spain, the annual production of mussel is 2×10^6 t (35% of the world). The industrial thermal treatment of mussels generates between 300 and 400 L/t wastewaters that are continuously disposed into the sea without previous treatment and or further reuse. These effluents, relatively rich in organic matter (7 g glycogen/L and 25 g COD/L), contribute to the progressive deterioration of the marine ecosystem. We wish to suggest a biotechnological process, based on a laboratory optimization and industrial pre-scale trials, to transform these industrial effluents into a growth culture medium to produce microbial biomass. Furthermore, this biomass is isolated and treated by different optimized separation and purification processes to produce several bioproducts: 1) single cell protein; 2) cell wall material with a high content in glucans and glycoproteins 3) fractions of 1,3-β-glucans and mannoproteins from yeast cell walls hydrolysis; and 4) a potential antioxidant extract. Finally, the authors propose a scaled process for its industrial application. In consequence, we believe that this work provides an environmentally friendly, eco-designed and profitable solution that allows integrating the mussel industry into the ecosystem in a sustainable way.

Abbasi et al., 2016. Anaerobic microbial fuel cell treating combined industrial wastewater: Correlation of electricity generation with pollutants. microbial fuel cell (MFC) is a new technology that not only generates energy but treats wastewater as well. A dual chamber MFC was operated under laboratory conditions. Wastewater samples from vegetable oil industries, metal works, glass and marble industries, chemical industries and combined industrial effluents were collected and each was treated for 98 h in MFC. The treatment efficiency for COD in MFC was in range of 85–90% at hydraulic retention time (HRT) of 96 h and had significant impact on wastewater treatment as well. The maximum voltage of 890 mV was generated when vegetable oil industries discharge was treated with columbic efficiency of 5184.7 C. The minimum voltage was produced by Glass House wastewater which was 520 mV. There was positive significant co-relation between COD concentration and generated voltage. Further research should be focused on the organic contents of wastewater and various ionic species affecting voltage generation in MFC.

Jacome 2016,Sustainable Energy from agro-industrial wastewaters in Latin-America. Conventional biological processes used to treat high-polluted agro-industrial effluents produce biogas and sludge, two by-products stocking up important energy contents. Advanced biotechnologies to treat these effluents are being developed to obtain increased biogas production and other efficient and useful energy sources, such as bio-hydrogen and even bio-electricity. Utilization of these clean energies is significantly lower than other renewable, particularly in developing regions such as Latin-America. This occurs despite the close link between the environmental benefits and sustainable use of this energy, which might be incorporated in different sustainable strategies for local and regional development. This study reviews the ′state of the art′ of Latin-American research regarding technologies for energy recovery from agro-industrial wastewaters and their sustainable implementation. It also discusses the need for a more sustainable management of the water-energy nexus in treatment systems used to decont minate effluents, which should be committed to the improvement of renewable energy production and to a more extended regional use. Contributions of methodologies based on life cycle assessment (LCA) and criteria-indicators used to drive sustainability studies in this field are updated and used to outline a conceptual framework advising sustainable practices in this sector.

Chapter three
Methodology

3.1 Introduction

This study involved characterization of the quality of raw industrial wastewater from clothes and halvah factories. The quality of treated water by anaerobic and coagulation sedimentation process. The characterization involved determination the physical and chemical quality parameters and heavy metals.

3.2 Wastewater sampling and analysis

A duplicate wastewater samples were collected weekly from the factories for a period of five months. The samples were collected from two points, the sampling activities were carried out during March to August 2016. At the end of this period three samples were collected. The Samples collected were immediately analyzed as they reached the laboratory for (TSS), (TDS), (COD) and (BOD5). The parameters pH, Electrical Conductivity (EC), Temperature (T) were determined in situ. After that the samples were filtered through 0.2 mm pore size membrane filter in order to remove suspended and insoluble particles then stored in polyethylene bottles and kept refrigerated at 4ºC until the time of analysis. Each sample was divided into two portions, one for major anion analyses to prevent any biological activity. The other portion was acidified with few drops of concentrated HNO_3(high purity) in order to minimize adsorption of metals on the container walls, also to retard chemical and biological changes for cation and heavy metal to prevent any change in ionic composition of the samples.

3.3 Chemical analyses

Chemical laboratory analyses were conducted in this study in order to show the amount of the pollution in the industrial wastewater from factory and after treatment. The main chemical quality parameters include (pH, EC, COD, BOD5,TOC,).

3.3.1 pH, Electrical Conductivity (EC)

The pH and EC was determined by using A portable pH-meter model WTW525, Portable EC-meter Model WTW LF 320 (WTW , Germany). These tests were done on site, as these values might change when transported to the laboratory. The pH, EC-meter were calibrated in the laboratory before use according to the standard method No 4500, 2510,(American public health association APHA,1995).

3.3.2 Biological Oxygen Demand (BOD5)

The Biological Oxygen Demand (BOD5) for industrial wastewater samples was determined according to standard No 5210 B.(APHA,1995). Biological Oxygen demand (BOD5) test measures the amount of Oxygen used by the microorganism as they utilize the organic material (carbonaceous demand) and inorganic material such as sulfide and ferrous iron in wastewater.

3.3.3 Chemical Oxygen Demand (COD)

The Chemical Oxygen Demand (COD) for wastewater samples of clothes and halvah factries was determined according to standard method No 5220 C. (APHA,1995). The chemical oxygen demand (COD) is used as measurement of the oxygen equivalent of the organic matter content of a sample that is susceptible to oxidation by strong chemical oxidant.

3.3.4 Total Organic Carbon (TOC)

The Total Organic Carbon (TOC) for wastewater samples of clothes and halvah factries was determined according to standard method No 5225 C. (APHA,1995). The Total Organic Carbon (TOC) is used as measurement of the organic matter content of a sample that is susceptible to oxidation by strong chemical oxidant.

3.4 Physical analyses

Physical laboratory analyses were conducted in this study in order to show the amount of the pollution in the industrial wastewater from factory and after treatment. The main physical quality parameters include (Temperature, TDS, TSS and TVS).

3.4.1Total Dissolved Solids (TDS)

The total dissolved solids (TDS) for industrial wastewater samples from both factories was determined according to standard method No 2540 C.(APHA, 1995). A 50 mL of well-mixed wastewater sample was filtered through filter paper, washed with successive volume of distilled water , allowing complete drainage between washings. Transfer total filtrate to a weighed evaporating dish and evaporate to dryness in an oven at 180±2C for at least 2 hours, cool in a desiccators to balance temperature, and weigh. Drying cycle is repeated until a constant weight is obtained.

a-Equipment

Filter paper (Whatman No.), porcelain evaporating dish 100ml, 50ml graduated cylinder, suction flask, Buchner funnel, analytical balance and oven.

b-Calculation

TDS=(A-B)×1000/sample volume, ml
Where:
A: weight of dried residue and dish in mg.
B: weight of dish in mg.

3.4.2 Total Suspended Solids (TSS)

The total suspended solids (TSS) for industrial wastewater samples from factries was determined according to standard method No 2540B.(APHA,1995). A 50mL of well-mixed wastewater sample was filtered through apre-weighed filter paper; wash with successive volume of distilled water, allowing complete drainage between washings. The filter paper was removed from filtration apparatus and transferred to aluminum weighing dish as a support. Then, dry for at least 2h at 103 to 105C in the oven, cool in a desiccators to balance temperature and weigh. Drying cycle is repeated until a constant weight is obtained.

3.4.3 Total volatile solid (TVS)

The total volatile solid (TVS) for industrial wastewater samples from factries was determined according to standard method No 2540G.(APHA,1995).

3.5 Analysis of Heavy Metals

Heavy metals (Cu, Pb, Zn, Fe, Cr and Mn) were analyzed using Flame Atomic Absorption Spectrophotometer (Shimadzu model AA-6200, Shimadzu, Japan).

3.5.1 Standards

Standard solutions of heavy metals (1000 mg/l), namely copper (Cu), zinc (Zn), Chromium (Cr), Iron (Fe), manganese (Mn) and lead (Pb) were procured from Merck. Solutions of varying concentrations were prepared for all the metals by diluting the standards.

Total metal (mg/Kg) = C(ppm)×Solution volume/Sample weight (g)
Where:
C= ppm metals obtained from the standard curve.

3.5.2 Calibration curves

A calibration curve of absorbance against concentration for each metal was prepared as shown in figure 3-1 for Fe, Cr, Pb, Zn, Mn and Cu respectively, which was yielded a good linearity figure (1) appendix(I). The instrument responded very well to the standard analyte of interest and therefore would respond to analyte in the samples. The calibration

curves were used for the determination of metal concentrations in the samples.

3.6 Treatment of industrial wastewater

Water that is used in industrial processes from steelmaking to agriculture, power generation and clothes manufacturing is inevitably changed by the process. Chemicals are added and byproducts are picked up as the water moves through the system. As a result, industrial wastewater often requires treatment to remove solids, oil and grease, bacteria, regulated chemicals and other substances before it can be reused or discharged to the environment. In this study two method were used for the treatment of IWW by anaerobic digestion and coagulation.

3.6.1Anaerobic Digester

The Armfield Anaerobic Digester is designed as a bench top training facility and as a means of providing operational process data for plant design purposes.

3.6.1.1 Anaerobic digestion Experiments

The effect of Hydraulic Retention Time HRT on removal efficiencie of the anaerobic digestion have be investigated by set of experiments.Four runs with different flow rates of 0.5, 1, 2, and 4.15 liter/day (corresponding to the HRT of 8, 7, 6 and 5 hr), respectively were conducted. The experiments were extended coninonsly from 16April. 2016 to August. 2016. All results of the anaerobic digester experiments are given in chapter four.

3.6.1.2 Technical specifications

Reactors	Two, identical reactors: Nominal capacity:5 litres Packed volume:4 litres 150mm dia ×250mm high
Reactor packing	25mm diameter Bio-balls
Temperature control	For each reactor:200W heating jacket with PID control from a temperature sensor positioned inside the reactor, set point within range ambient to 55 C, the jacket is thermostatically protected by a cut-out set at 85 C.
Feed pumps	Two, identical peristaltic pumps: variable speed using 10 turn potentiometer to 4rpm supplied with three tube diameters, 1.6, 3.2 and 4.00mm, flow rates from 0.2 to 5.8 l/day.
Gas collection vessels	Two, identical linear scale, 0-5 liter capacity.

3.6.1.3 Process studies

Broadly speaking the anaerobic process may be divided into two distinct stages,(1) the hydrolysis of large molecular species into acetic acid and (2) the conversion of the acetic acid into methane and carbon dioxide. This two stage process can be demonstrated by operating the two reactors in series, one to produce volatile acids from the initial substrate – acidogenesis and the second to convert the volatile acids into methane and carbon dioxide – methanogenesis. In addition the following basic differencies of the two stages of the process can be demonstrated: (a) the low level of methanogenic (b) the low level of COD removal exhibited by the acidogenic stage compared with the methanogenic stage.

3.7 Coagulation and sedimentation process

In this experiment, alum used as coagulant by different dosages of 0, 6.667,33.335 and 66.67mg/liter are added to the four flasks containing industrial wastewater samples. These experiments were carried out to determine the optimum concentration of alum .

Chapter Four
Results and Discussions

The result in Table (4.1) and Table (4.2) show the characteristics of IWW in clothes and halvah factories. From the presented results the produced wastewater have high concentration of organic matter which might adversely affect the performance of the existing treatment plant. Therefore pretreatment of industrial wastewater before it reach the treatment plant is of high important. Two treatment methods were suggested anaerobic oxidation of organic matter and removal of suspended and colloids organic using coagulation process.

Table(4.1).
Characteristics of clothes company wastewater

Parameters	Units	value Average
PH		6.7
Temperature	ºC	21-25
Total dissolved solid (TDS)	mg/l	2500
Electrical Conductivity (EC)	µs/cm	1452
Total suspended solid (TSS)	mg/l	644
Chemical Oxygen Demand (COD)	mg/l	1730
Biological Oxygen Demand (BOD)	mg/l	860
Flow	m3/day	210
Total organic carbon (TOC)	mg/l	1332
Total volatile suspended solid (TVS)	mg/l	1277

Table(4.2).
Characteristics of halvah company wastewater

Parameters	Units	Average Value
PH		6.89
Temperature	ºC	22
Total dissolved solid (TDS)	mg/l	2141
Electrical Conductivity (EC)	µs/cm	1200
Total suspended solid (TSS)	mg/l	460
Chemical Oxygen Demand (COD)	mg/l	1460
Biological Oxygen Demand (BOD)	mg/l	710
Flow	m3/day	12
Total organic carbon(TOC)	mg/l	1045
Total volatile suspended solid (TVS)	mg/l	1451

4.1 Results of anaerobic digester experiments

4.2 physical Parameters:

Temperature, TSS, TDS, TVS

The statistical summary of the physical parameters of the effluent industrial wastewater through treatment by anaerobic digester are shown in Table (4.3) and Table (4.4).

The Temperature of industrial wastewater during operation of the device is in a state increase during the period of the device for 21 days for a sample. The temperature value of clothes factory is ranged from 27ºC to 41ºC with average value of 34ºC for R1 and from 28.4ºC to 42.3ºC with average value 35.35ºC for R2 treated wastewater and temperature for halvah factory is ranged from 21ºC to 35ºC with average value 28ºC for R1 and from 25ºC to 37ºC with average value 31ºC for R2 treated wastewater. The Total dissolved solid (TDS) result showed higher concentration in the effluent IWW from factories , 2500mg/l of clothes factory 2141mg/l of halvah factory after anaerobic treatment the result showed reduction in the concentration. The Total Suspended Solids (TSS) showed a higher concentration in the effluent wastewater from the factories it was at clothes factory of 644 mg/l while at halvah factory the concentration of the effluent wastewater was 460 mg/l According to Jordanian standards this is a very high value. The reduction of TSS is due to settling of suspended solid in the reactors. The Total volatile solid (TVS) showed a higher concentration in the effluent of IWW from the factories it was at clothes factory of 1277 mg/l while at halvah factory the concentration of effluent IWW was 1451 mg/l. The reduction of TVS is due to after anaerobic digestion as shown in the table(4.3) and table(4.4).

Table(4.3)

Statistical summary of the physical parameter of the effluent wastewater from anaerobic digester for clothes factory.

	Reactor 1				Reactor2			
parameter	**Min**	**Max**	**Aver**	**STD**	**Min**	**Max**	**Aver**	**STD**
Temperature(℃)	27	41	34	0.02	28.4	42.3	35.35	0.033
TSS(mg/l)	296	640	468	0.17	217	591	404	331
TDS(mg/l)	1539	2444	1991.5	141	1347	2251	1799	139
TVS(mg/l)	420	1112	766	64	333	964	648.5	51

Table(4.4)
Statistical summary of the physical parameter of the effluent wastewater from anaerobic digester for halvah factory.

	Reactor 1				Reactor2			
Parameter	**Min**	**Max**	**Aver**	**STD**	**Min**	**Max**	**Aver**	**STD**
Temperature(℃)	21	35	28	0.01	25	37	31	20.5
TSS(mg/l)	281	452	366.5	0.15	262	411	336.5	253
TDS(mg/l)	1520	2040	1780	133	1311	1982	1646.5	161.2
TVS(mg/l)	630	1245	937.5	92	411	871	641	45

4.2 Chemical Parameters

PH , EC, COD , TOC and BOD

Statistical summary of the COD and TOC of the effluent wastewater from anaerobic digester after treatment is shown in table(4.5) and Table(4.6) For pH although it seems that there is a wide variation in the collected samples as it ranged from 5.3to 6.6 with an average value of 5.95 for the R1 wastewater and from 5.2 to 6.2 with a average value of 5.7 for the R2 treated wastewater for clothes factory and pH for halvah factory is ranged from 5.4 to 6.7 with average value 6.05 for the R1 wastewater and from 5.2 to 6.2 with average value 5.7 for R2. The tests of pH showed that acidic wastewater due to the anaerobic process that occurs inside the reactor as a result of bacterial activity.

For Electrical Conductivity (EC) showed a wide range and similar to pH. It ranged from 652 to 1450µS/cm with an average concentration of 1051 µS/cm for the R1 wastewater and from 410 to 1442 µS/cm with a average value of 926 µS/cm for the R2 treated wastewater for clothes factory and EC for halvah factory is ranged from 614 to 1090 µS/cm with average value of 852 µS/cm for R1 wastewater and from 511 to 922 µS/cm with average value of 716.5 µS/cm for R2 treated wastewater. High value of EC were the same sample showed as pH value the supporting the idea of using detergents at that days which was soluble in water increasing its EC value.

The COD showed a wide variation within the sampling period as it ranged from 610 to 1130 ppm for the effluent wastewater from R1 with a average value of 870 ppm. However the effluent showed similar variation as it ranged from 261 to 1112 ppm with a average value of 685.5 ppm for the R2 water for clothes factory and COD value for halvah factory it was for R1 ranged from 725ppm to 993ppm with average value 859ppm and for R2 it ranged from 511ppm to 977ppm and average value 744ppm.Higher variation in total organic carbon TOC was detected for the sampling period as it ranged from 327ppm to 1030 ppm for the effluent wastewater with a average value of 678.5ppm for R1 and ranged

value from 290ppm to 985ppm with average value 637.5ppm for R2 for clothes factory while the value of TOC of the halvah factory it was ranged from 466ppm to 921ppm with average value 693.5ppm for R1 and ranged value 400ppm to 879ppm with average value 639.5ppm for R2.
This indicated that the removal efficiency of industrial wastewater after treatment by anaerobic digester was 84.913 % of COD and 72.9% of TOC for clothes factory and 65% of COD 74% of TOC for halvah factory.

Statistical summary of the BOD of the effluent wastewater at anaerobic digester after treatment is ranged value for clothes factory it was 310ppm to 710ppm with average value 510 ppm for R1 and ranged value 282ppm to 580ppm with average value 431ppm for R2 while halvah factory the BOD5 ranged value it was 378ppm to 692ppm with average value 535 ppm for R1 and ranged value 250 ppm to 580 ppm with average value 415 ppm

Table(4.5)
Statistical summary of the pH, EC, COD, TOC and BOD5 parameter of the effluent wastewater from anaerobic digester for clothes factory.

	Reactor 1				Reactor 2			
Parameter	**Min**	**Max**	**Aver**	**STD**	**Min**	**Max**	**Aver**	**STD**
pH	5.3	6.6	5.95	0.28	5.2	6.2	5.7	0.55
EC (µs/cm)	652	1450	1051	282	410	1442	926	134
COD (mg/l)	610	1130	870	176.5	261	1112	685.5	166
TOC (mg/l)	327	1030	678.5	161.2	290	985	637.5	220
BOD5(mg/l)	310	710	510	122	282	580	431	130

Table(4.6)
Statistical summary of the pH, EC, COD, TOC and BOD5 parameter of the effluent wastewater from anaerobic digester for halvah factory.

	Reactor 1				Reactor 2			
Parameter	**Min**	**Max**	**Aver**	**STD**	**Min**	**Max**	**Aver**	**STD**
PH	5.4	6.7	6.05	0.33	5.2	6.2	5.7	0.21
EC(µs/cm)	614	1090	852	464	511	922	716.5	178.3
COD(mg/l)	725	993	859	420.3	511	977	744	431
TOC(mg/l)	466	921	693.5	333	400	879	639.5	230
BOD5(mg/l)	378	692	535	190	250	580	415	110

4.3 Methane gas (CH4)

The resulted from anaerobic digestion because the bectria oxidation organic matter which founded in industrial wastewater. The CH4 collected and the value of Statistics every day Table (12) and Table (13) appendix (II).

4.4 Heavy Metals

Table(4.7)
heavy metals concentration effluent IWW from clothes factory and halvah factory.

Element	Clothes Factory(mg/l)	Halvah Factory(mg/l)
Cu	0.858	0.711
Pb	0.7546	0.5322
Zn	0.1006	0.0977
Fe	2.368	1.6241
Cr	0.6222	0.4691
Mn	0.589	0.649

Summary of Pb, Mn, Fe, Cr, Cu and Zn concentration in the effluent wastewater from anaerobic digester after treatment is shown in Table (4.7) and Table(4.8). For Cu concentration at effluent industrial wastewater from anaerobic digester it was for clothes factory was ranged from 0.0315ppm to 0.0841ppm with average value 0.0578ppm for R1 and ranged value from 0ppm to 0.0211ppm with average value 0.01055ppm for R2 and Cu concentration for halvah factory it was ranged from 0.6222ppm to 0.708ppm with average value 0.6651ppm for R1 and ranged value from o.5303ppm to o.6433ppm with average value 0.5868ppm.

For the concentration of Pb for clothes factory ranged from 0.5276ppm to 0.2751ppm with average concentration of 0.40135 ppm for R1 and ranged value from 0.1692ppm to 0.3889ppm with average value 0.27905ppm for R2 and the Pb concentration for halvah factory it was ranged from 0.1852ppm to 0.2101ppm with average value 0.19765ppm for R1and ranged value from 0.1162ppm to 0.1872ppm with average value 0.1517ppm for R2. For the concentration of Zn for clothes factory it was r ranged value from 0.1495ppm to 0.065ppm with average concentration of 0.10765ppm for R1 and ranged value 0.0779ppm to 0.1073ppm with average value 0.0926ppm for R2 the Zn concentration for halvah factory it was ranged from 0.0499ppm to 0.0549ppm with average value0.0524 ppm for R1and ranged value from 0.0371ppm to 0.0439ppm with average value 0.1517ppm for R2. For the concentration of Fe for clothes factory it was r ranged value from 0.9331ppm to

0.6623ppm with average concentration of 0.7977ppm for R1 and ranged value 0.1105ppm to 0.4678ppm with average value 0.288915ppm for R2 the Fe concentration for halvah factory it was ranged from 0.3309ppm to 0.4166ppm with average value0.37375 ppm for R1and ranged value from 0.2256ppm to 0.3051ppm with average value 0.26535ppm for R2. For the concentration of Cr for clothes factory it was r ranged value from 0.4311ppm to 0.1798ppm with average concentration of 0.30545ppm for R1 and ranged value 0.1026ppm to 0.2741ppm with average value 0.18835ppm for R2 and the Cr concentration for halvah factory it was ranged from 0.0297ppm to 0.1001ppm with average value0.0649 ppm for R1and ranged value from 0.0133ppm to 0.0846ppm with average value 0.0495ppm for R2. For the concentration of Mn for clothes factory it was ranged value from 0.2779ppm to 0.1251ppm with average concentration of 0.2015ppm for R1 and ranged value 0.1283ppm to 0.2015ppm with average value0.1649 ppm for R2 and the Mn concentration for halvah factory it was ranged from 0.4077ppm to 0.6973ppm with average value0.5525 ppm for R1and ranged value from 0.3258ppm to 0.561ppm with average value 0.44695ppm for R2.

Table (4.8)

Statistical summary of the heavy metals concentrations in ppm of effluent wastewater at anaerobic digester for clothes factory.

	Reactor1				Reactor2			
Parameter	**Min**	**Max**	**Aver**	**STD**	**Min**	**Max**	**Aver**	**STD**
Cu	0.0315	0.0841	0.0578	0.04	0	0.0211	0.01055	0.022
Pb	0.2751	0.5276	0.40135	0.15	0.1692	0.3889	0.27905	0.11
Zn	0.0658	0.1495	0.10765	0.01	0.0779	0.1073	0.0926	0.231
Fe	0.6623	0.9331	0.7977	0.031	0.1105	0.4678	0.28891	0.52
Cr	0.1798	0.4311	0.30545	0.015	0.1026	0.2741	0.18835	0.048
Mn	0.1251	0.2779	0.2015	0.039	0.1283	0.2015	0.1649	0.066

Table (4.9)

Statistical summary of the heavy metals concentrations in ppm of effluent wastewater at anaerobic digester for halvah factory.

	R1				R2			
Parameter	**Min**	**Max**	**Aver**	**STD**	**Min**	**Max**	**Aver**	**STD**
Cu	0.6222	0.708	0.6651	0.13	0.5303	0.6433	0.5868	0.844
Pb	0.1852	0.2101	0.19765	0.28	0.1162	0.1872	0.1517	0.191
Zn	0.0499	0.0549	0.0524	0.111	0.0371	0.0439	0.0405	0.599
Fe	0.3309	0.4166	0.37375	0.67	0.2256	0.3051	0.26535	0.391
Cr	0.0297	0.1001	0.0649	0.044	0.0133	0.0846	0.04895	0.049
Mn	0.4077	0.6973	0.5525	0.87	0.3258	0.5681	0.44695	0.442

4.5 Coagulation and Sedimentation

To decrease the concentration of organic material and heavy metals in the treated wastewater coagulation process was suggested using alum (Al2(SO4)3.18H2O). In this study alum was used as coagulant sedimentation to reduce the concentration of organic material and heavy metals the treated industrial wastewater.

4.5.1 Chemical Oxygen Demand (COD)

Initially removal of COD was rapid that within 1 day more than 4% of COD was removed afterward the removal was around 13% increased with time as the surface of alum was occupied with some organic mater. optimum contact time can be considered 4 days.

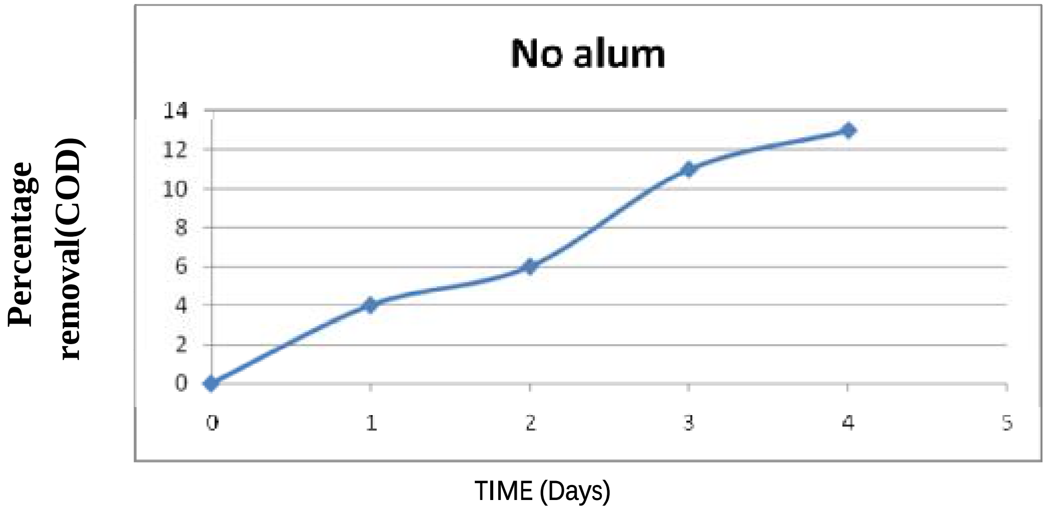

Figure (4.1)
Percent Removal COD with time at 0 mg/l (Alum)

When 6.667 mg/l of alum placed 1liter wastewater, there was adsorbed of organic matter for the 1st 1day as 17% of COD was .However, afterward an increase of COD was observed with time which can be due to dissolution of COD from the alum into solution. optimum contact time 4days it is 32%.

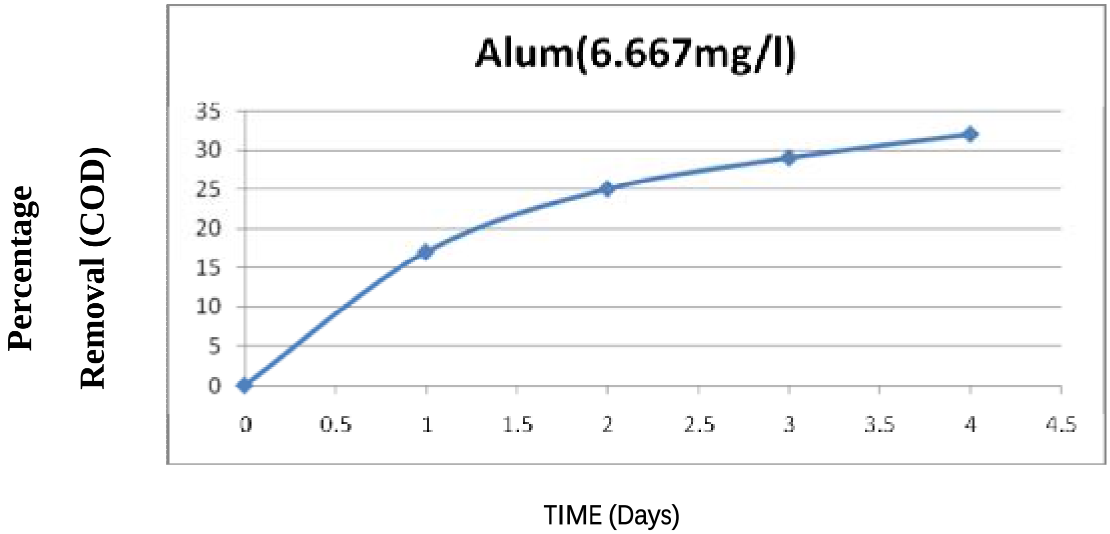

Figure (4.2)
Percent Removal COD with time at 6.667 mg/l (Alum)

Removal of organic mater was rapid that within 1 day more than 12% of COD was removed afterward the removal was around 37% decreased with time as the surface of alum was occupied with some COD. optimum contact time can be considered 4 days.

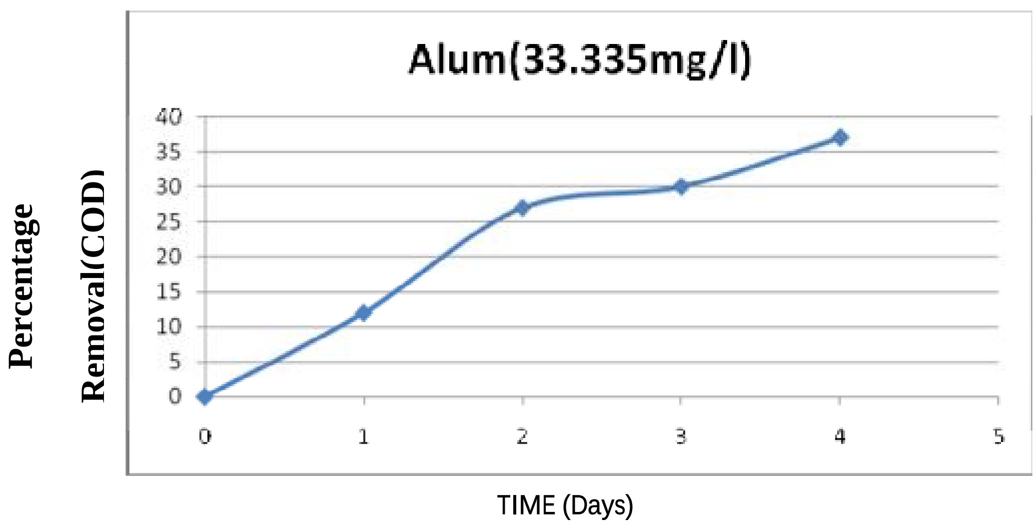

Figure (4.3)
Percent Removal COD with time at 33.335 mg/l (Alum)

Removal of organic mater was rapid that within 1 day more than 15% of COD was removed afterward the removal was around 40% decreased with time as the surface of alum was occupied with some COD. optimum contact time can be considered 4 days.

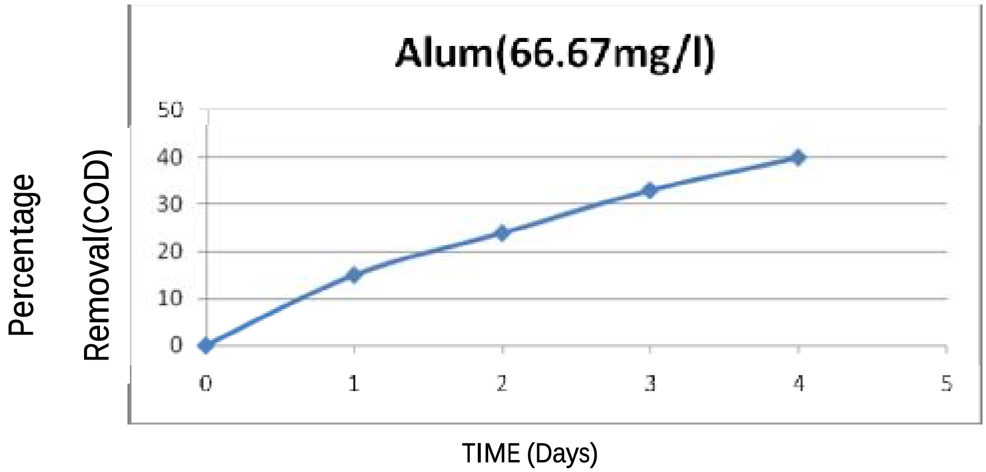

Figure (4.4)
Percent Removal COD with time at 66.67mg/l (Alum)

4.5.2 (Heavy metals)

An attempt was done to investigate the removal of heavy metals using alum as an adsorbent.

For Pb, when using 0, 6.667mg/l, 33.335mg/l, and 66.67mg/l of alum as Figure
(4.21),(4.22), (4.23) and (4.24) the removal of Pb was rapid that within the first concentration. as more than 18% of Pb was on the alum and for 6.667mg/l the maximum value of efficiency 22% and for 33.335mg/l the maximum value 26% and for 66.67mg/l the maximum value of efficiency removal 30%.

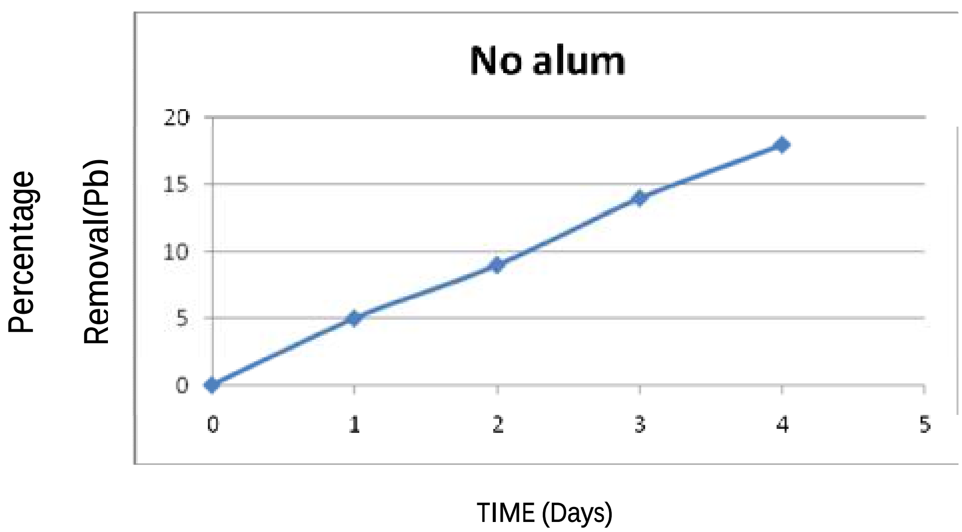

Figure (4.5)
Removal percentage of Pb using 0 mg/l of alum (contact time 4days)

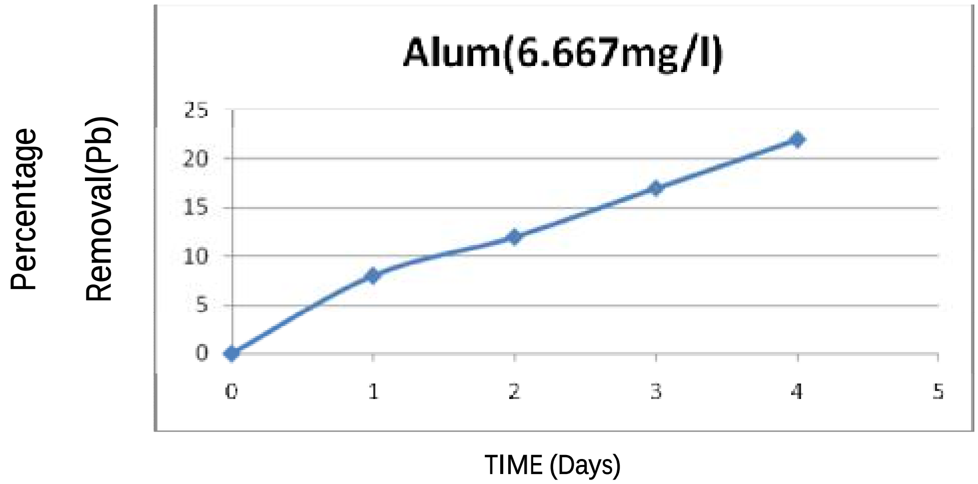

Figure (4.6)
Removal percentage of Pb using 6.667 mg/l of alum (contact time 4days)

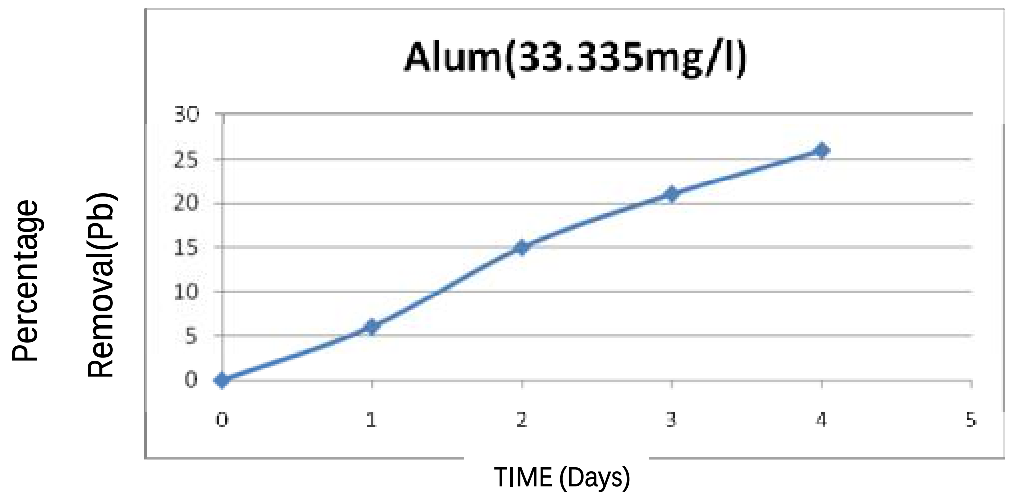

Figure (4.7)
Removal percentage of Pb using 33.335 mg/l of alum (contact time 4days)

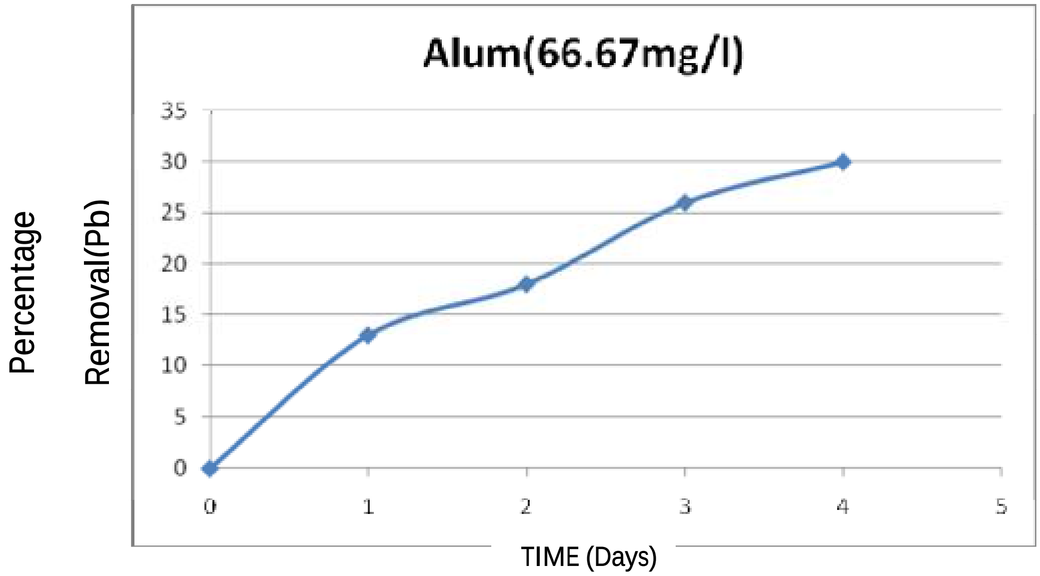

Figure (4.8)
Removal percentage of Pb using 66.67 mg/l of alum (contact time 4days)

For Fe, when using 0, 6.667mg/l, 33.335mg/l, and 66.67mg/l of alum as (Figure 4.25), (4.26), (4.27) and (4.28) the removal of Fe was rapid that within 4days. more than 40% of Fe was settling by the alum.

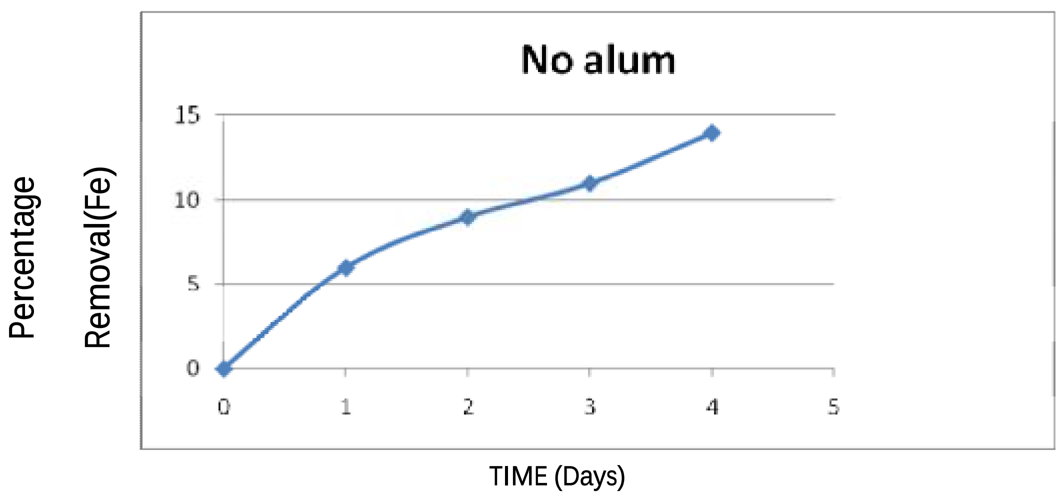

Figure (4.9)
Removal percentage of Fe using 0 mg/l of alum (contact time 4days)

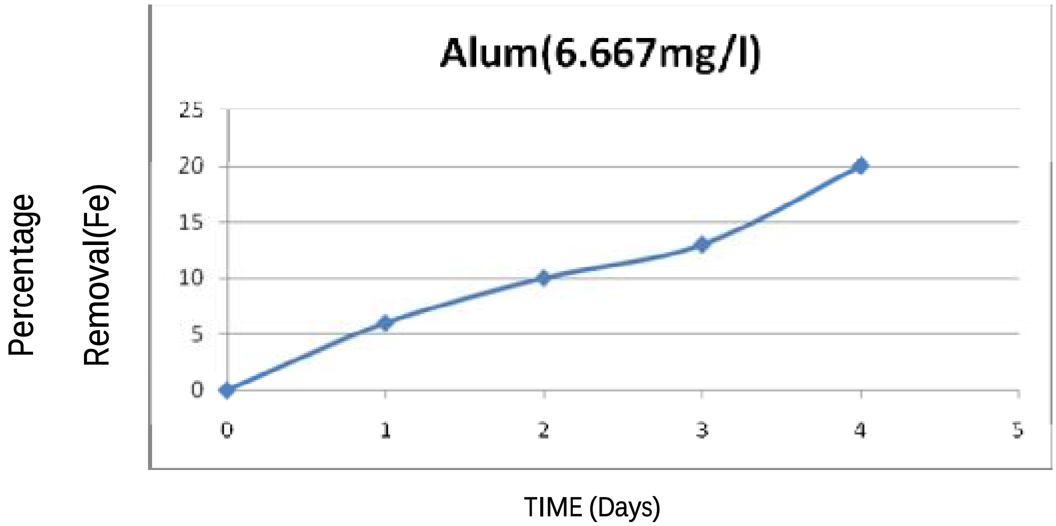

Figure (4.10)
Removal percentage of Fe using 6.667 mg/l of alum (contact time 4days)

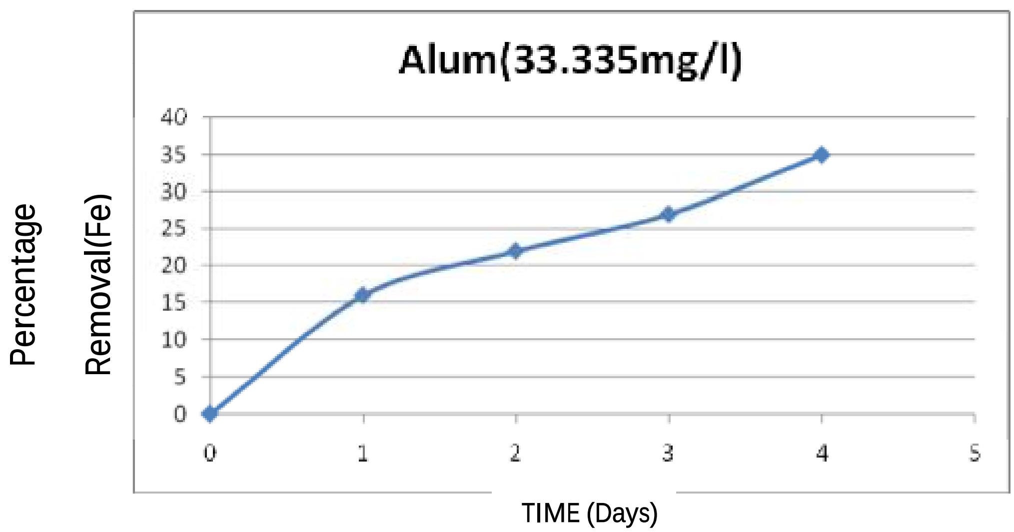

Figure (4.11)
Removal percentage of Fe using 33.335 mg/l of alum (contact time 4days)

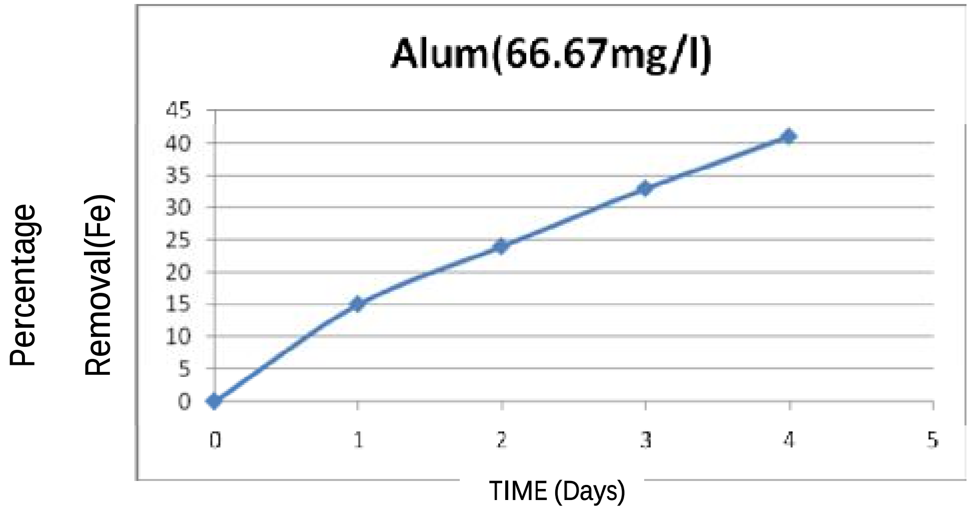

Figure (4.12)
Removal percentage of Fe using 66.67 mg/l of alum (contact time 4days)

For Cu, when using 0, 6.667mg/l, 33.335mg/l, and 66.67mg/l of alum as (Figure 4.29),(4.30),(4.31) and (4.32) the removal of Cu was rapid that within 4days. more than 46% respectively of Cu was settling by the alum.

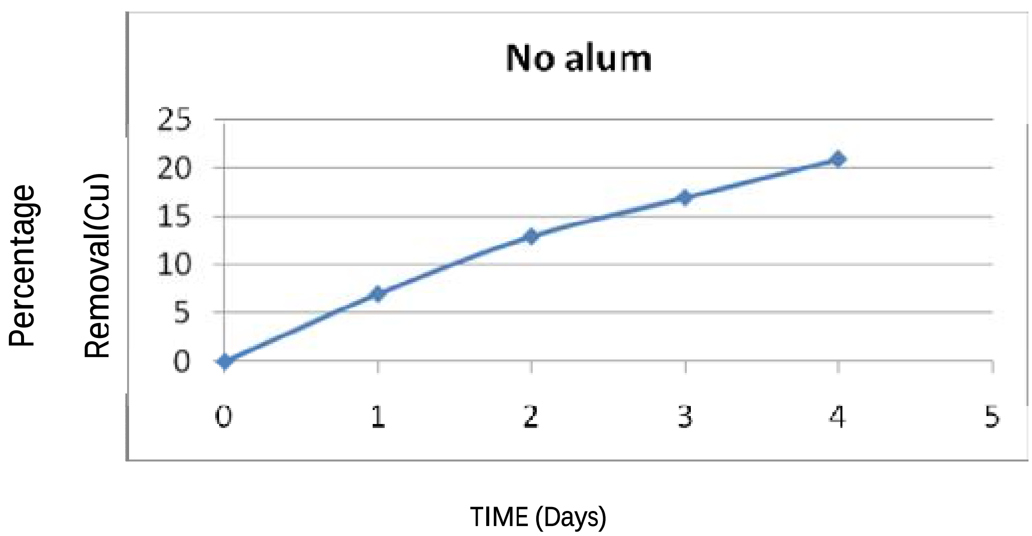

Figure (4.13)
Removal percentage of Cu using 0 mg/l of alum (contact time 4days)

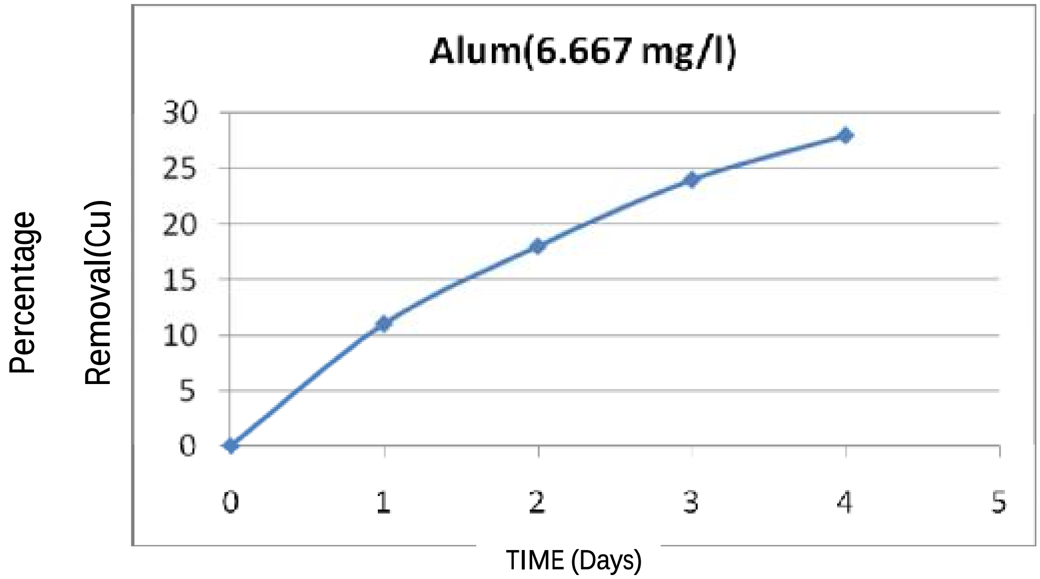

Figure (4.14)
Removal percentage of Cu using 6.667 mg/l of alum (contact time 4days)

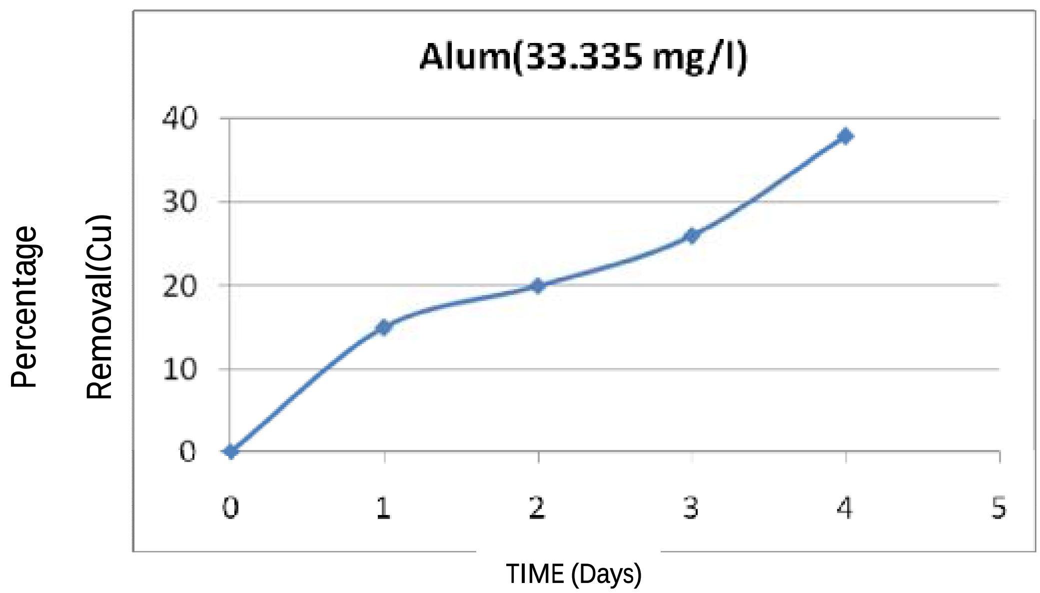

Figure (4.15)
Removal percentage of Cu using 33.335 mg/l of alum (contact time 4days)

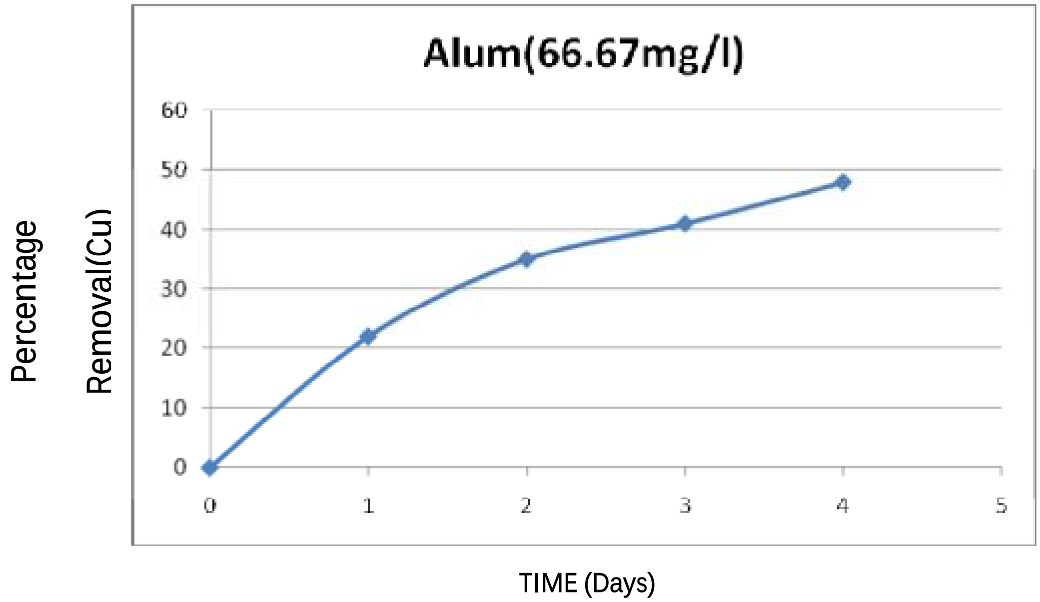

Figure (4.16)
Removal percentage of Cu using 66.67 mg/l of alum (contact time 4days)

For Cr, when using 0, 6.667mg/l, 33.335mg/l, and 66.67mg/l of alum (Figure 4.33),(4.34),(4.35) and (4.36) the removal of Cu was rapid that within 4days. more than 33% respectively of Cu was settling by the alum.

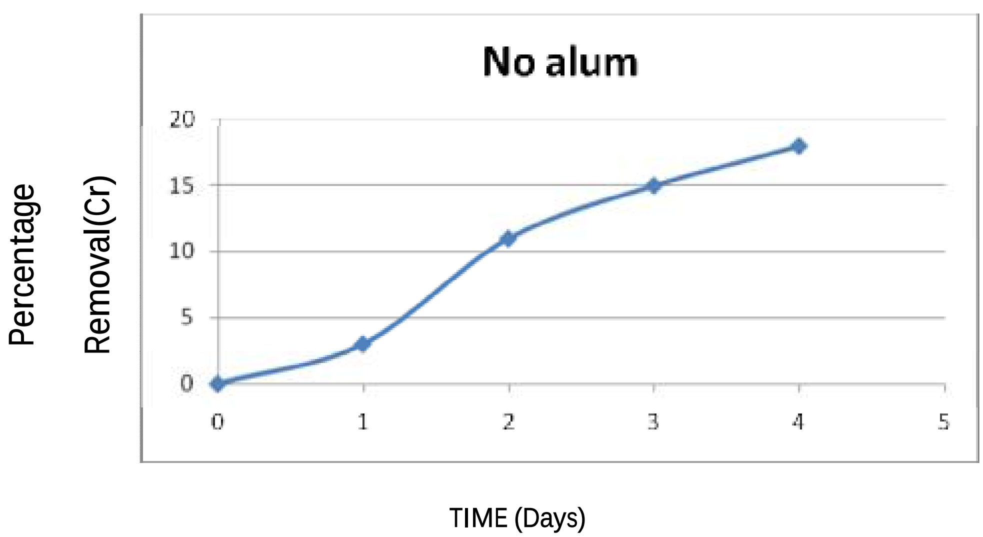

Figure (4.17)
Removal percentage of Cr using 0 mg/l of alum (contact time 4days)

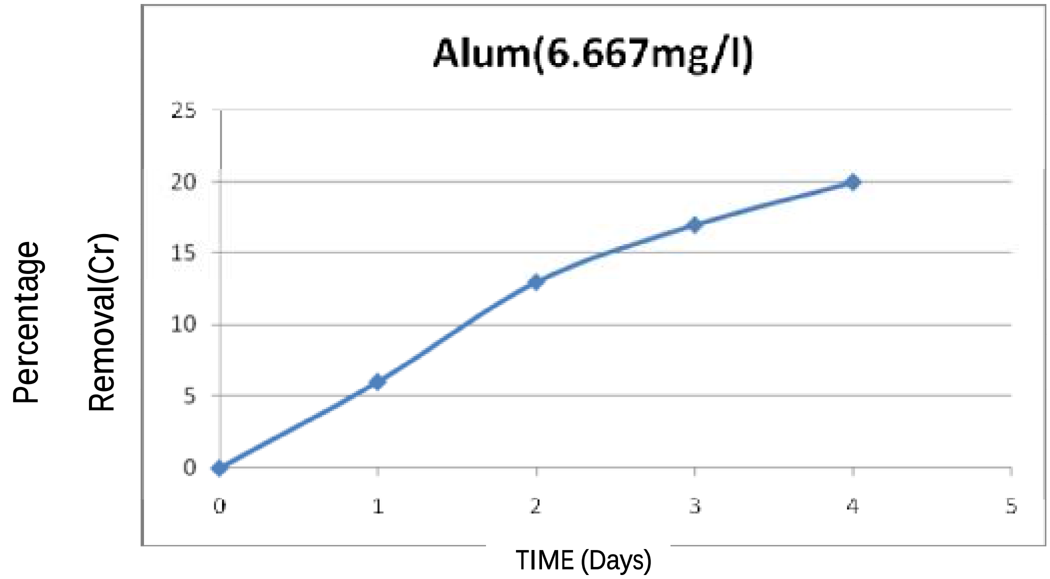

Figure (4.18)
Removal percentage of Cr using 6.667 mg/l of alum (contact time 4days)

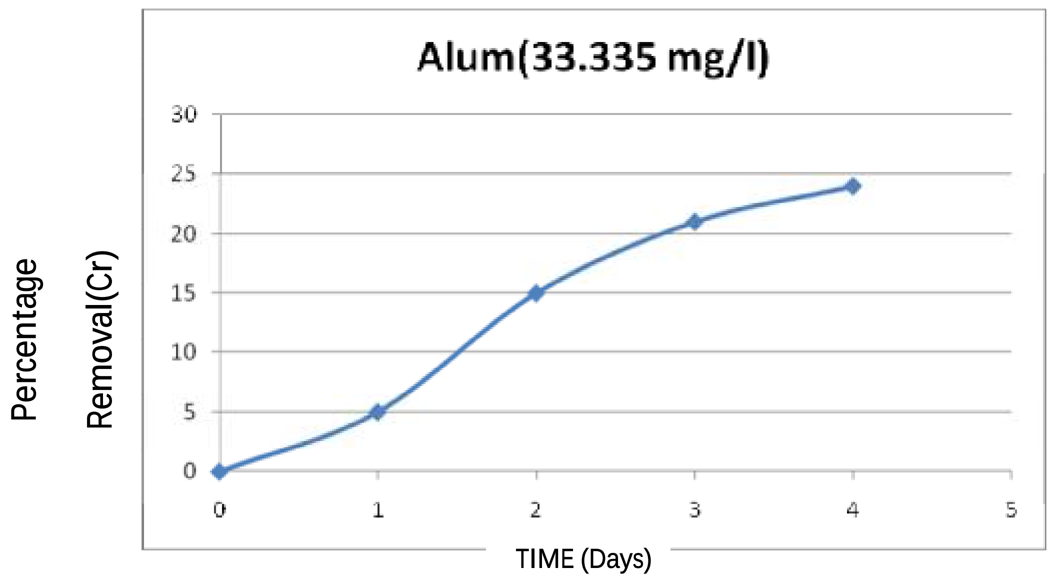

Figure (4.19)
Removal percentage of Cr using 33.335 mg/l of alum (contact time 4days)

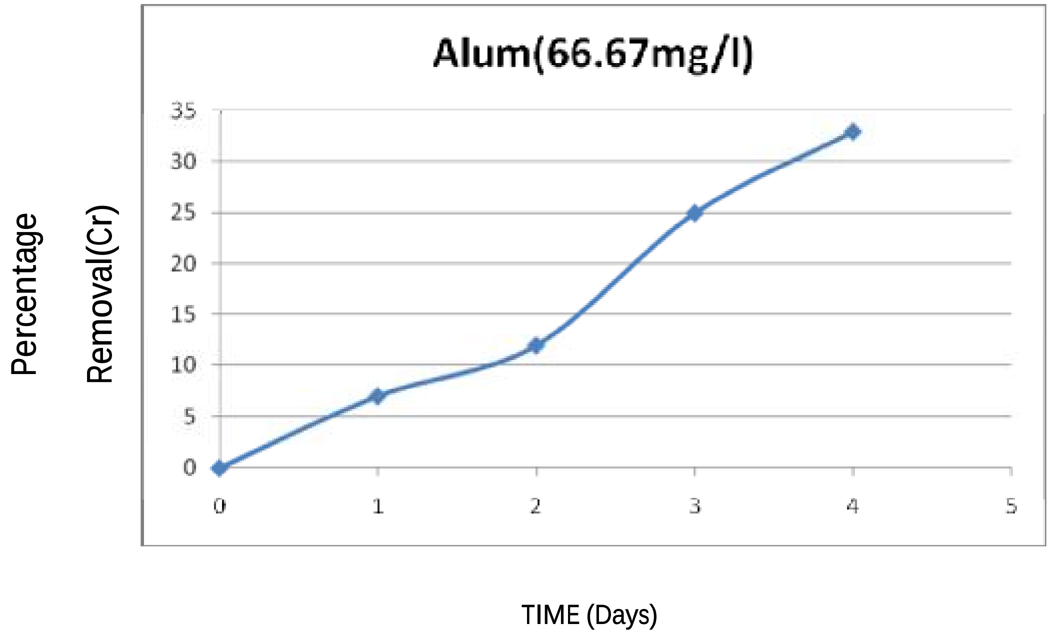

Figure (4.20)
Removal percentage of Cr using 66.67 mg/l of alum (contact time 4days)

4.5.3 Settling velocity

For the design of the clarifier must be choose optimum settling velocity. The result showed the optimum settling velocity get when added 33.335 mg/l from alum.

Area of clarifier = Flow(m^3/day) / Settling velocity(m/day)

Table(4.10)
settling velocity for coagulation sedimentation process

No.	Weight of alum (mg/l)	Settling Velocity (cm/hr)
1	0	2.35
2	6.667	2.13
3	33.335	2.6
4	66.67	2.44

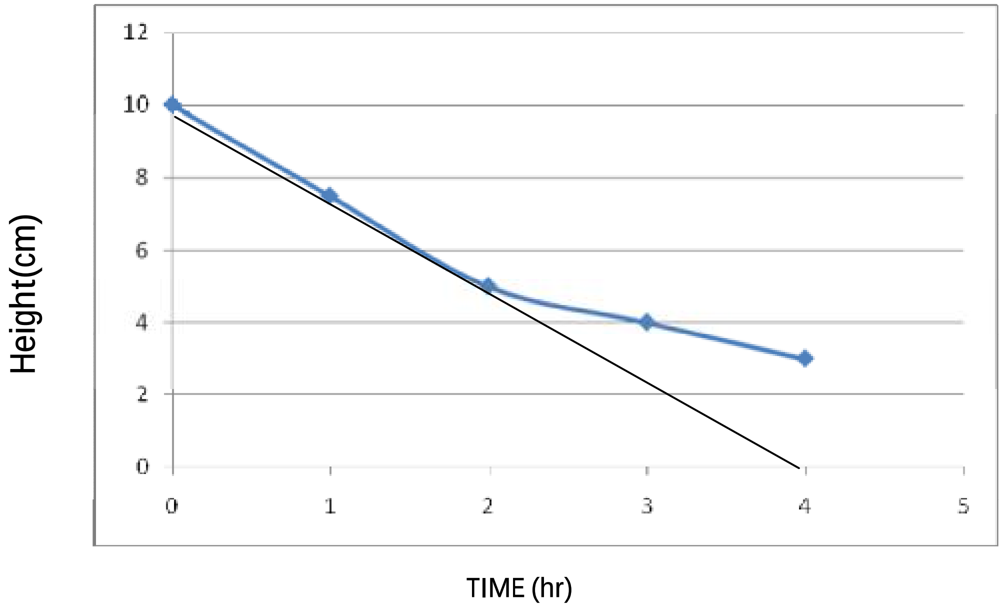

Figure (4.21)
Settling curve (Alum 0 mg/l)

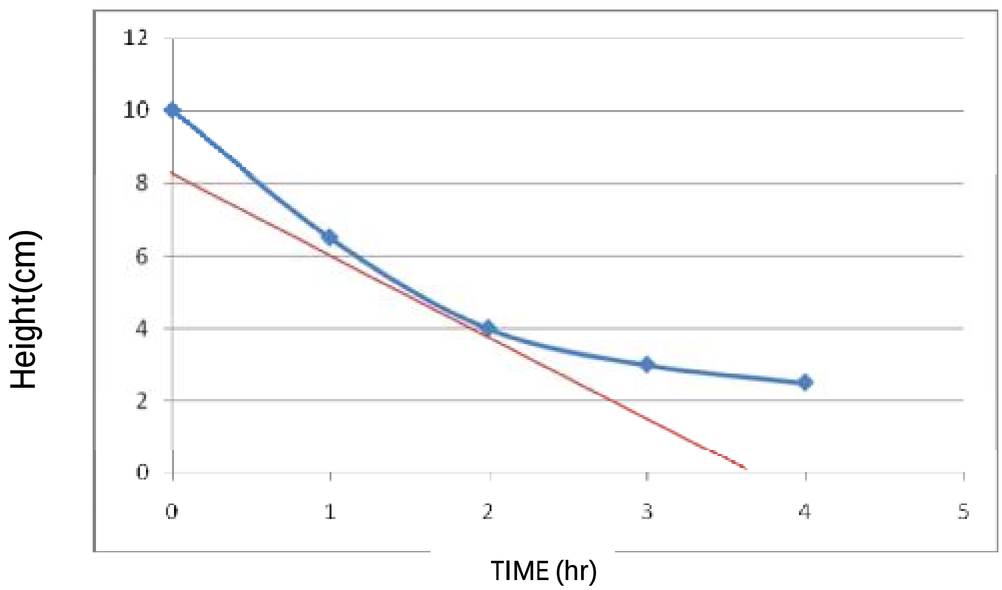

Figure (4.22)
Settling curve (Alum 6.667 mg/l)

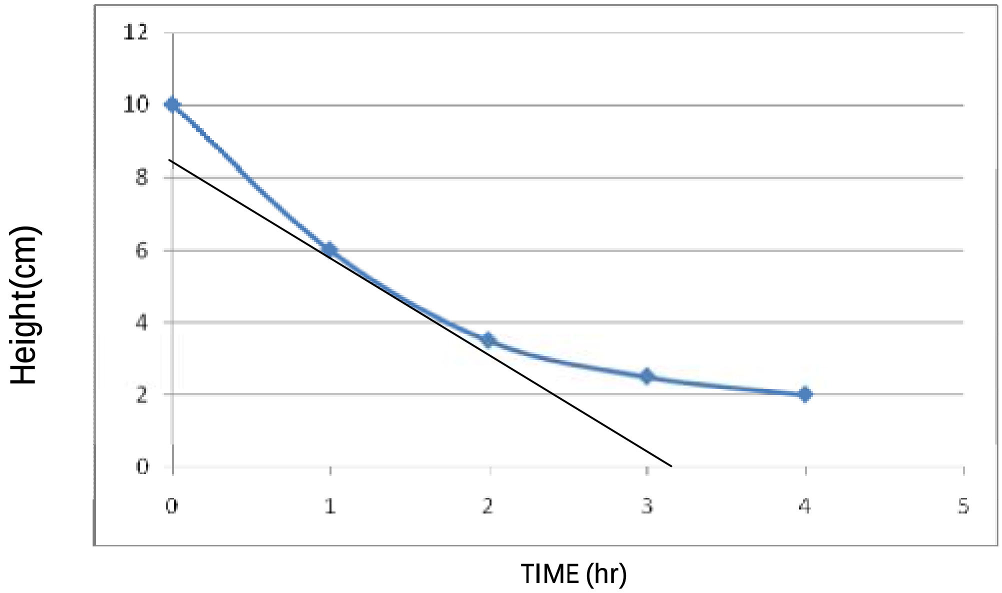

Figure (4.23)
Settling curve (Alum 33.335 mg/l)

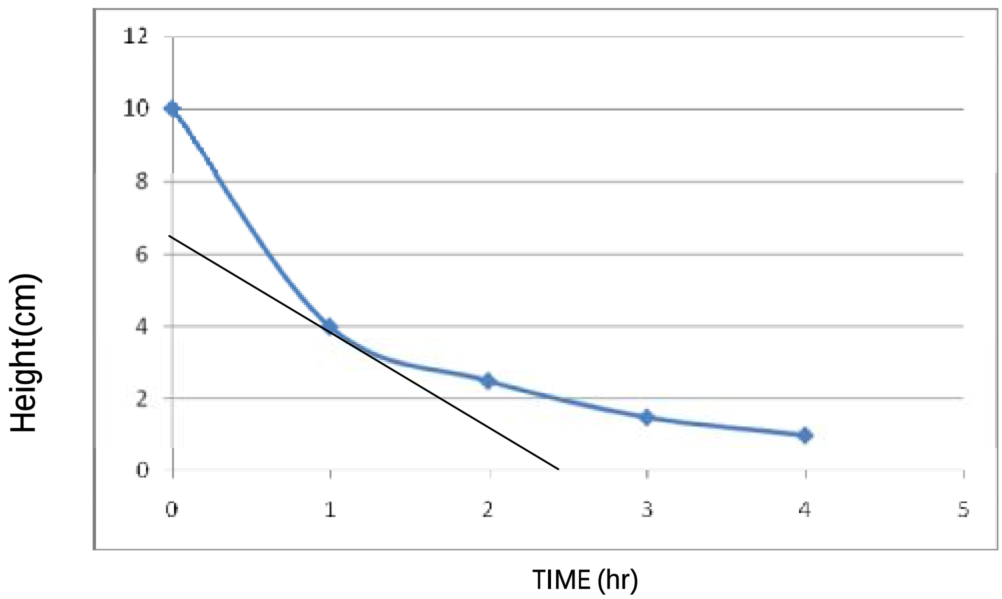

Figure (4.24)
Settling curve (Alum 66.67 mg/l)

4.6 Design of tank for pretreatment
Flow in anaerobic digester = 4.15 L/day
Flow for effluent from clothes factory = 210 m^3/day
Flow for effluent from halvah factory = 12 m^3/day
Volume of reactor = 4 Liter
Detention time = volume of reactor/ flow
= 4 / 4.15 = 0.964 day
Total flow for effluent from factories = 210+12 = 222 m^3/day
Volume of tank =D.T * total flow
= 0.964 * 222 = 214m^3

Use two tanks, volume for every tank = 107m^3

Let.
Length of tank = 2width
Depth of tank = 15m
Volume of tank = Length * Width * Depth
107 = 2width * width * 15
107 = 30width * width
Width = 2 m
Length = 4 m
Depth = 15 m

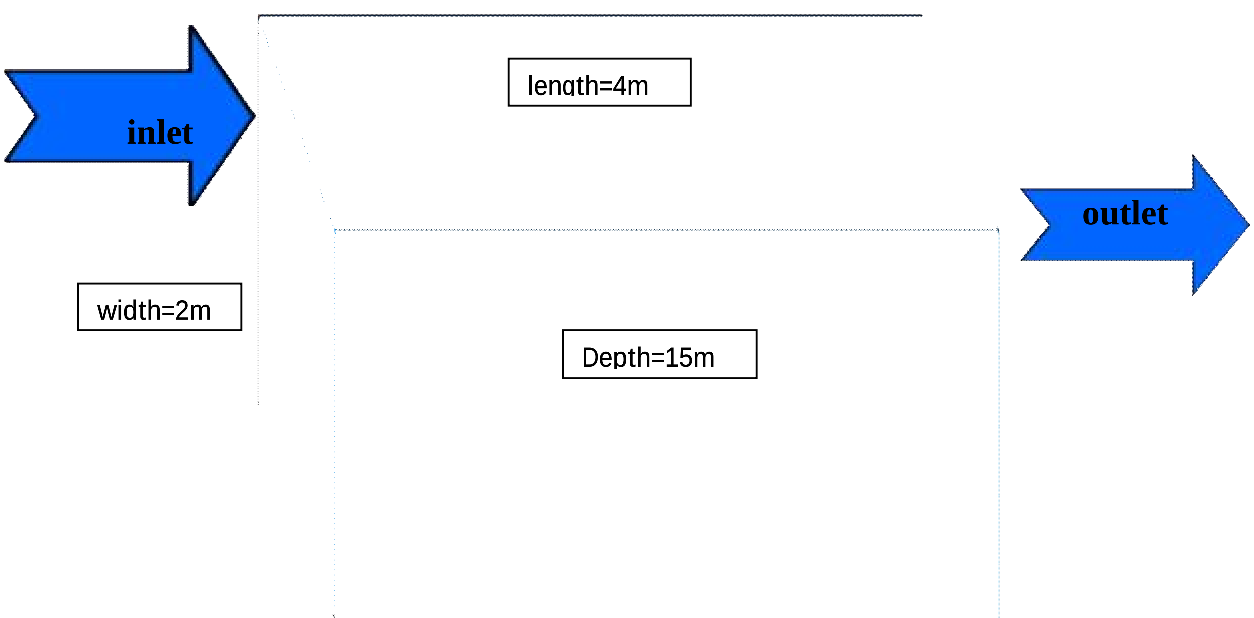

Figure (4.25)
Design tank for anaerobic treatment

4.7 Conclusions

From the present work, the following main points my be concluded:

1. The characteristics of effluent industrial wastewater from the clothes and halvah factories showed high concentration in organic matter and heavy metals.
2. Anaerobic oxidation treatment is effective for treatment of industrial wastewater produced from clothes and halvah factories.
3. The coagulation and sedimentation method effective for treatment of industrial wastewater and can be used for the removal of certain heavy metals.
4. The average concentration of heavy metals in industrial wastewater effluent from clothes and halvah factories are high due to the type of raw material used.
5. For anaerobic experiments, the average removal efficiencies were: (25.04-31.67%),(82.081-84.913%),(36.25-57.86%),(25.1–36.54%) for BOD5, COD, TSS and TDS respectively.

4.8 Recommendations

1. It is recommended pretreatment the industrial wastewater effluent from factories to decrease the concentration of organic matter and heavy metals before going to the existing treatment plant.
2. Further investigation on industrial wastewater quality should be encourage indeed especially regarding organic pollutants.
3. It is recommended use of methane gas (CH_4) generated as a result of anaerobic treatment process in electric power generation.

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Appendix (I)
Figures

INSTURMENTS

The following instruments are used in this study:

1. PH meter /Ph3110/WTW (Germany).
2. Conductivity meter.
3. Atomic Absorption Flame Emission Spectrophotometer.
4. Electrical Balance (Sartorius lab – TE214S, Germany).
5. Anaerobic Digester (Armfield).
6. Sedimentation process by using Alum.

figure (I.1) PH meter

figure (I.2) Conductivity meter

figure(I.3) Atomic Absorption Flame Emission Spectrophotometer

Figure(I.4)Electrical Balance
(Sartorius lab – TE214S, Germany)

Figure(I.5) Anaerobic Digester

Figure(I.6) Sedimentation process by using Alum

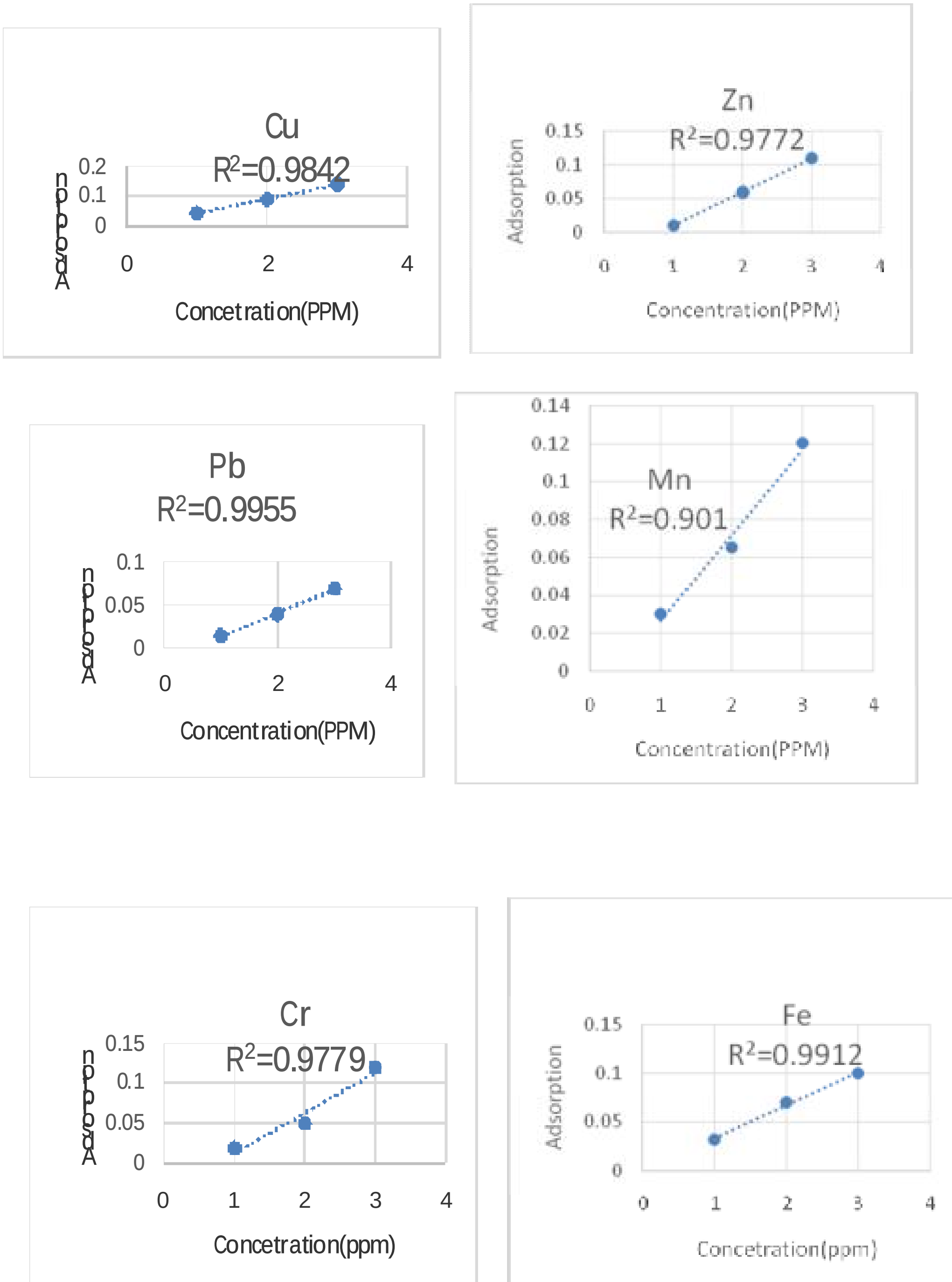

Figure (1)
Calibration curve of heavy metals for atomic adsorption

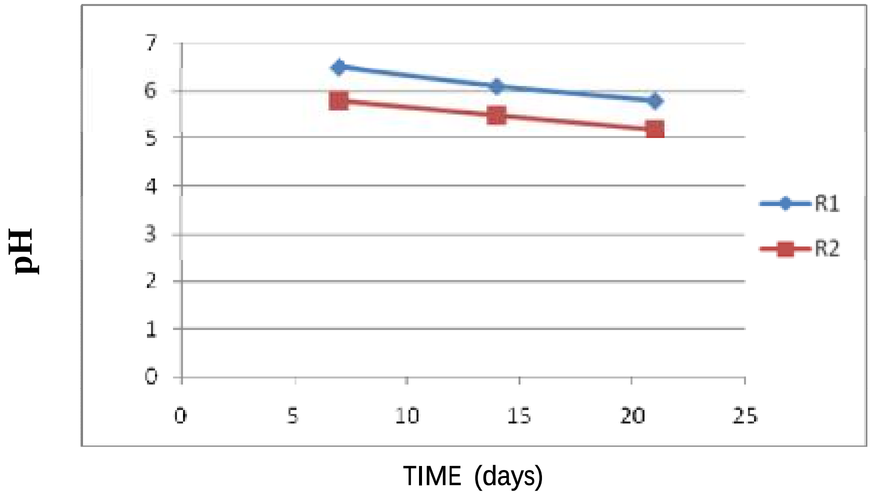

Figure (2)
pH value of the industrial wastewater after treatment experiment(1) clothes factory.

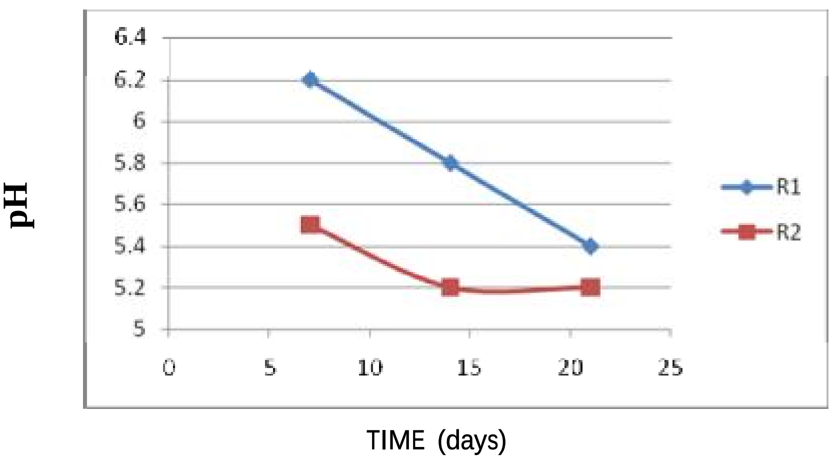

Figure (3)
pH value of the industrial wastewater after treatment experiment(2) clothes factory.

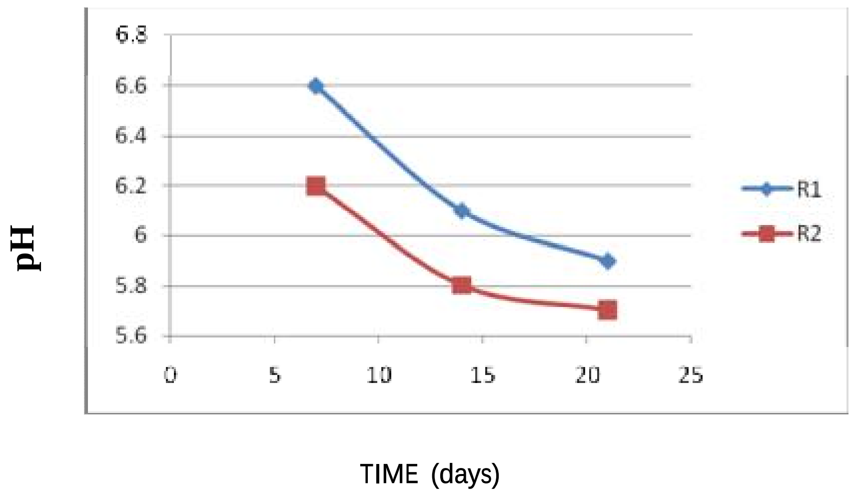

Figure (4)
pH value of the industrial wastewater after treatment experiment(3) clothes factory.

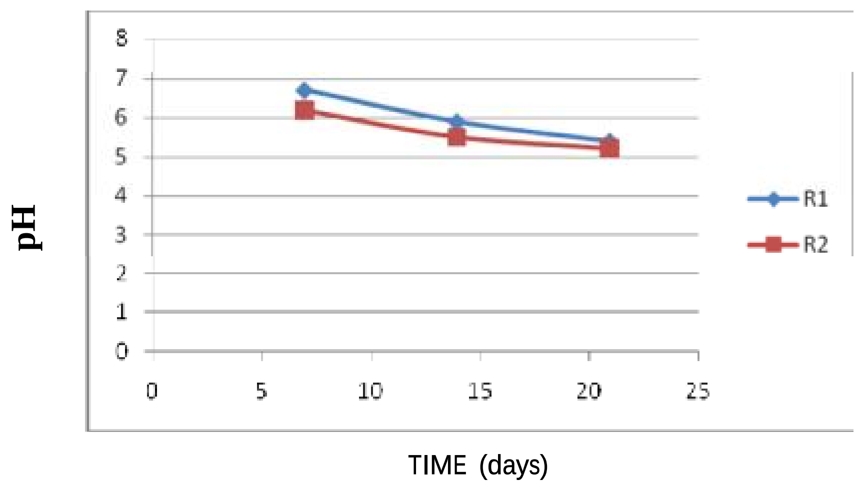

Figure (5)
pH value of the industrial wastewater after treatment experiment(1) halvah factory.

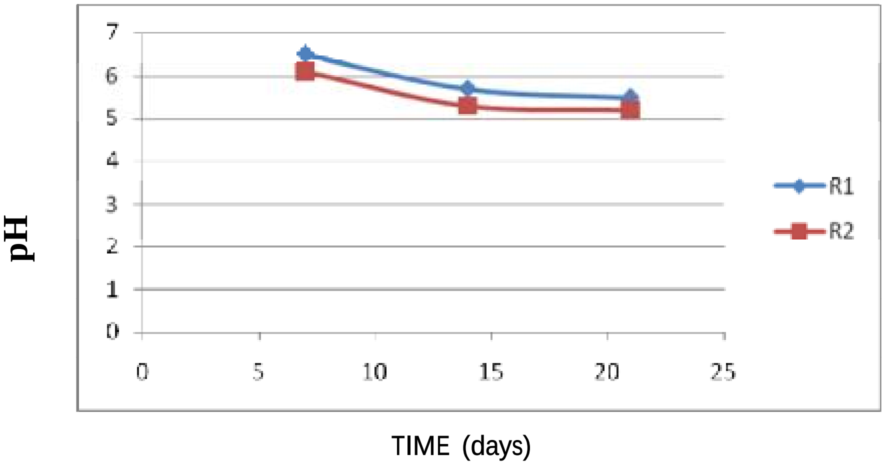

Figure (6)
pH value of the industrial wastewater after treatment experiment(2) halvah factory.

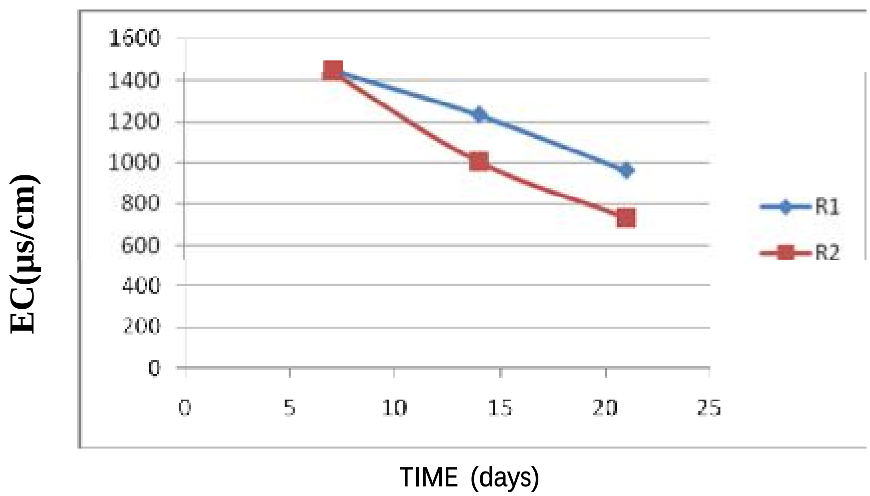

Figure (7)
EC value of the industrial wastewater after treatment experiment(1) clothes factory.

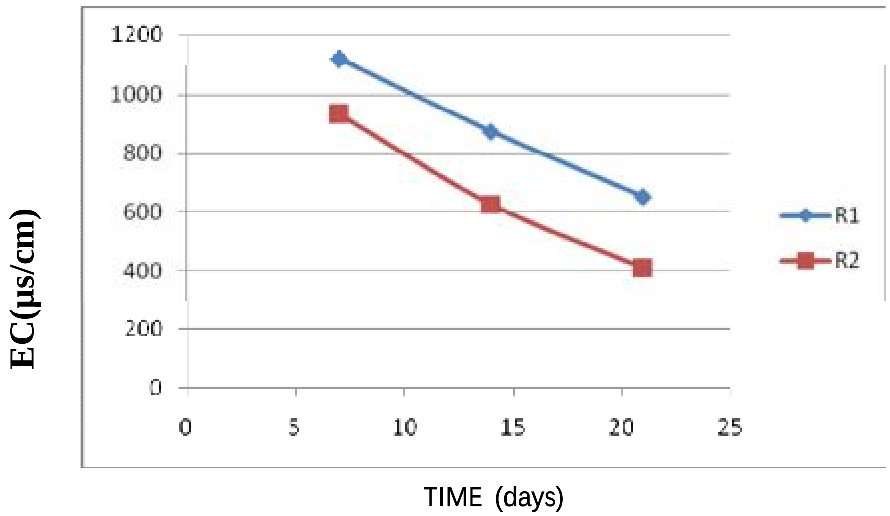

Figure (8)

EC value of the industrial wastewater after treatment experiment(2) clothes factory

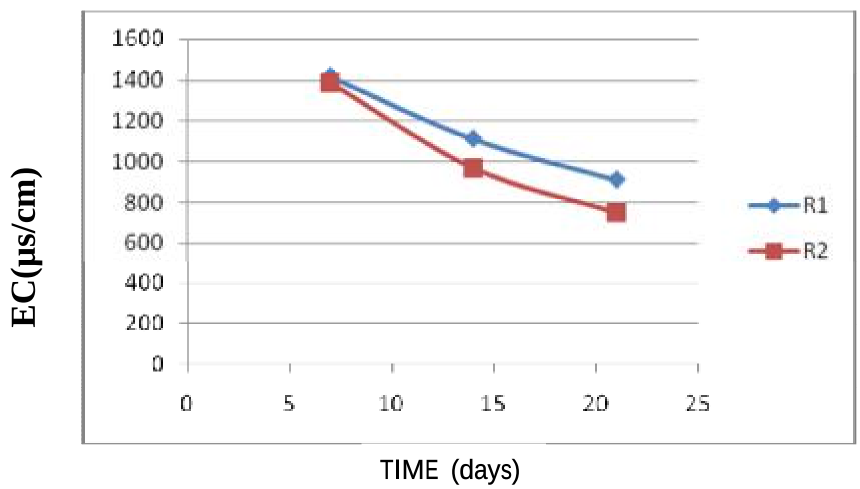

Figure (9)

EC(µs/cm) value of the industrial wastewater after treatment experiment(3) clothes factory

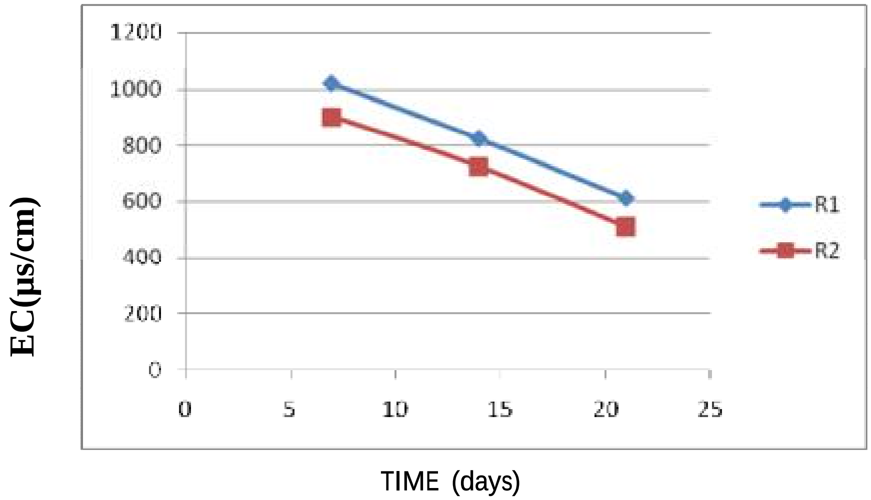

Figure (10)
EC(µs/cm) value of the industrial wastewater after treatment experiment(1) halvah factory.

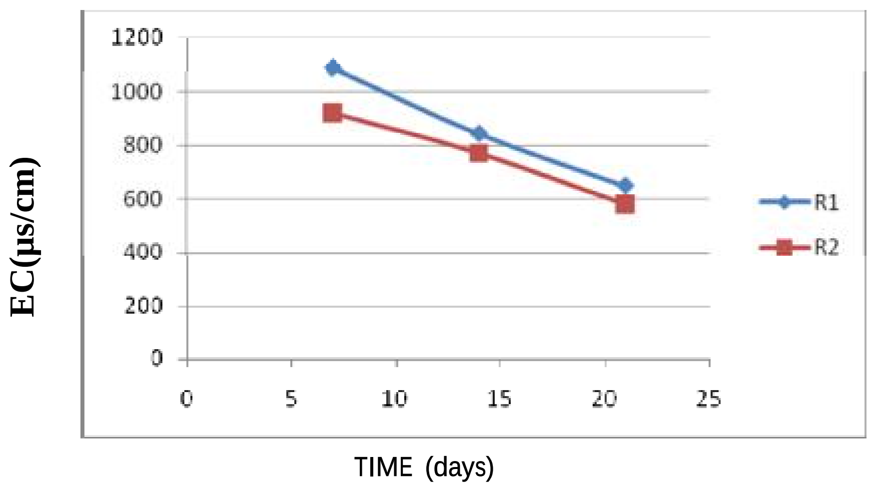

Figure (11)
EC(µs/cm) value of the industrial wastewater after treatment experiment(2) halvah factory.

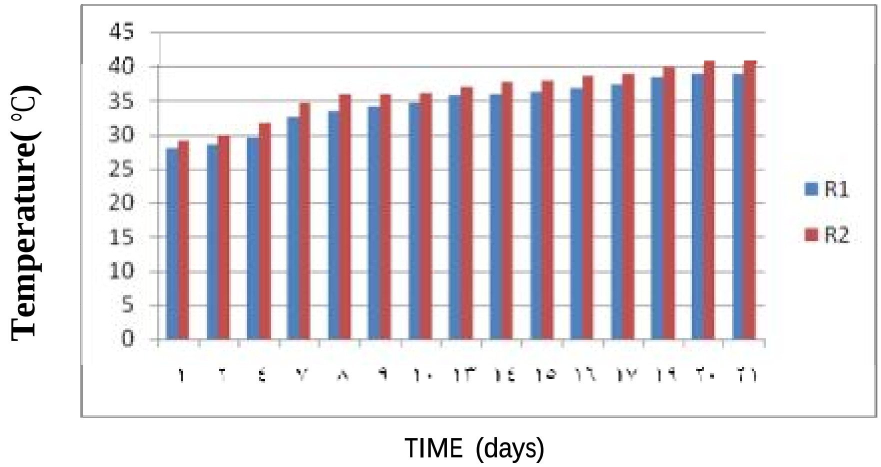

Figure (12)

Temperature(℃) value of the industrial wastewater after treatment experiment(1) clothes factory

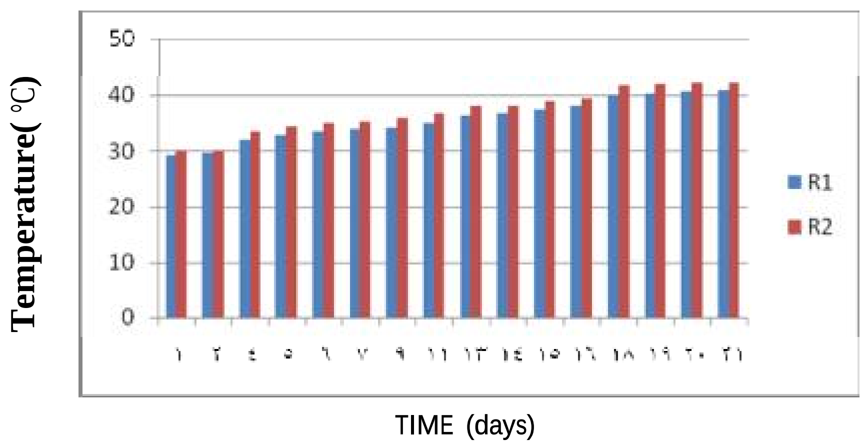

Figure (13)

Temperature(℃) value of the industrial wastewater after treatment experiment(2) clothes factory

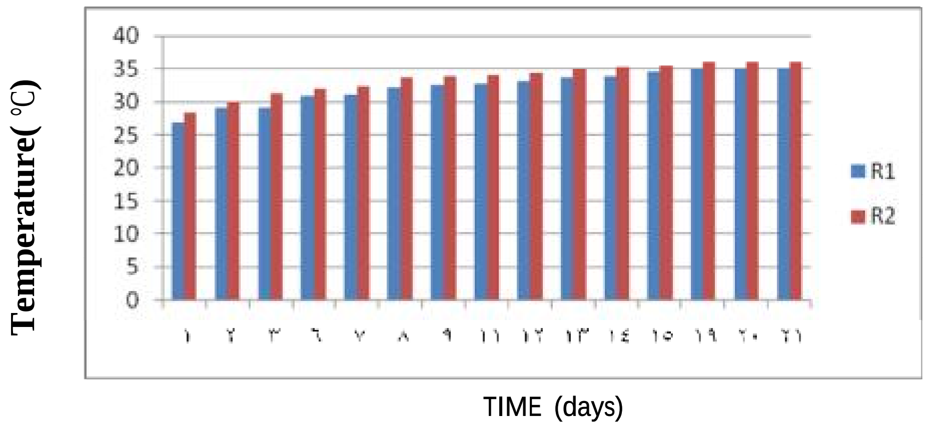

Figure (14)

Temperature(℃) value of the industrial wastewater after treatment experiment(3) clothes factory

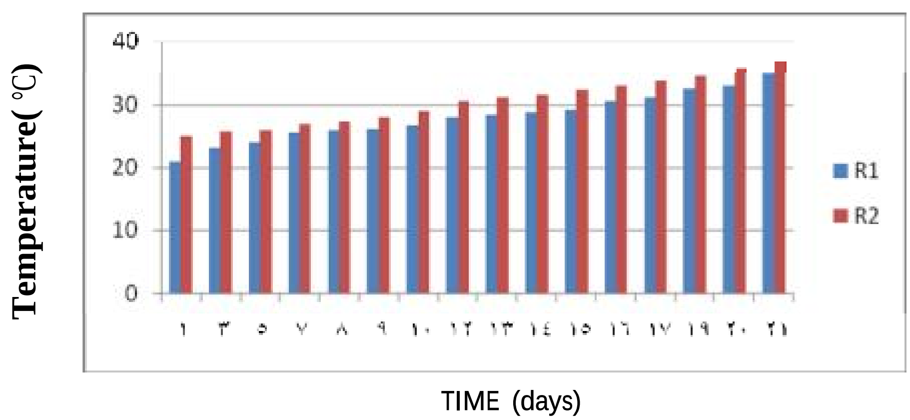

Figure (15)

Temperature(℃) value of the industrial wastewater after treatment experiment(1) halvah factory.

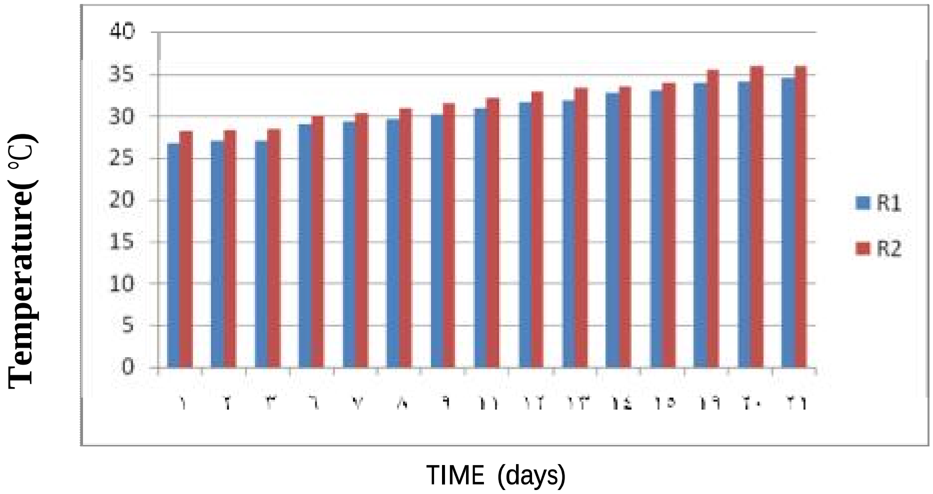

Figure (16)
Temperature(℃) value of the industrial wastewater after treatment experiment(2) halvah factory.

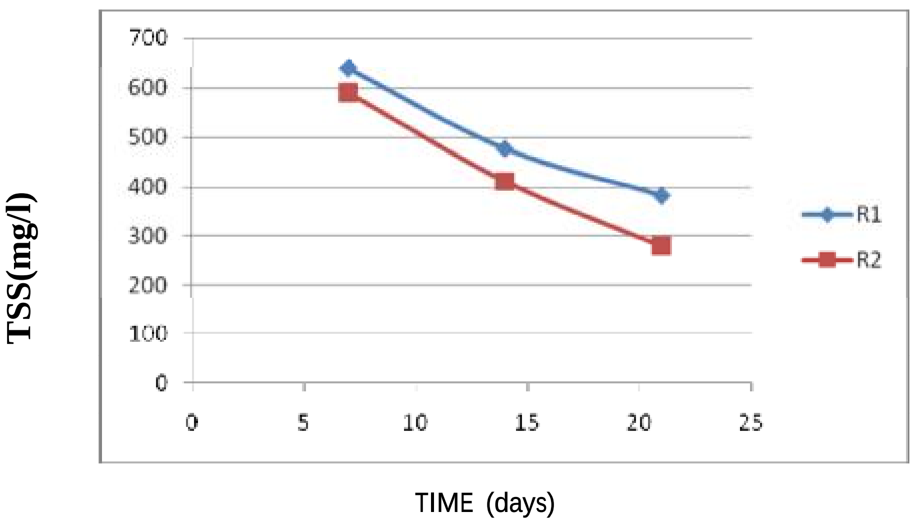

Figure (17)
TSS(mg/l) value of the industrial wastewater after treatment experiment(1) clothes factory

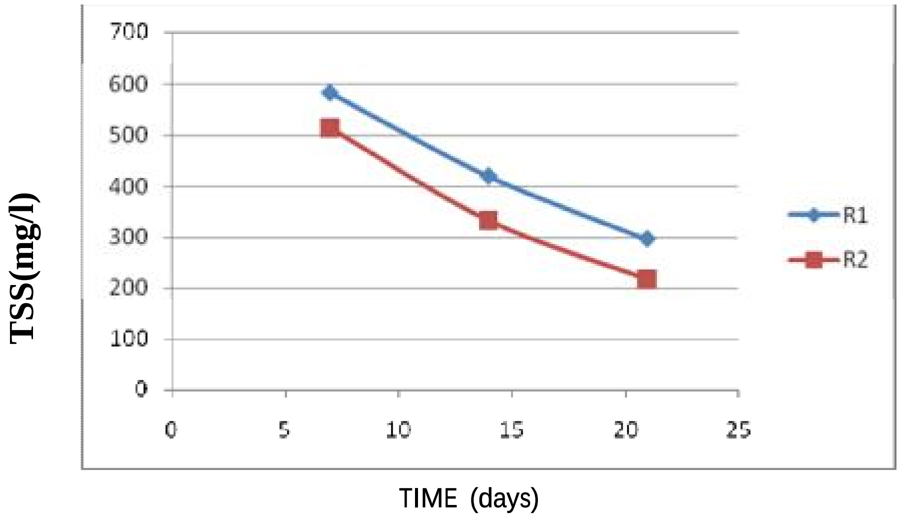

Figure (18)
TSS(mg/l) value of the industrial wastewater after treatment experiment(2) clothes factory

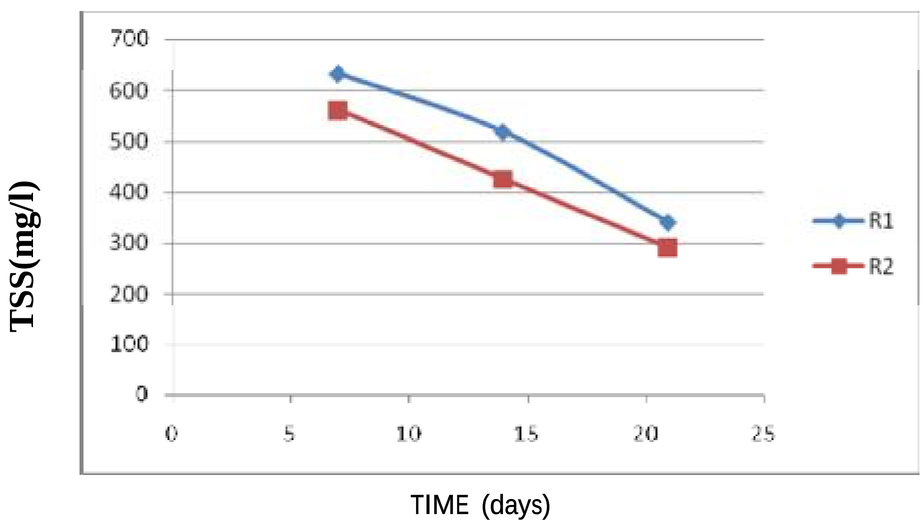

Figure (19)
TSS(mg/l) value of the industrial wastewater after treatment experiment(3) clothes factory

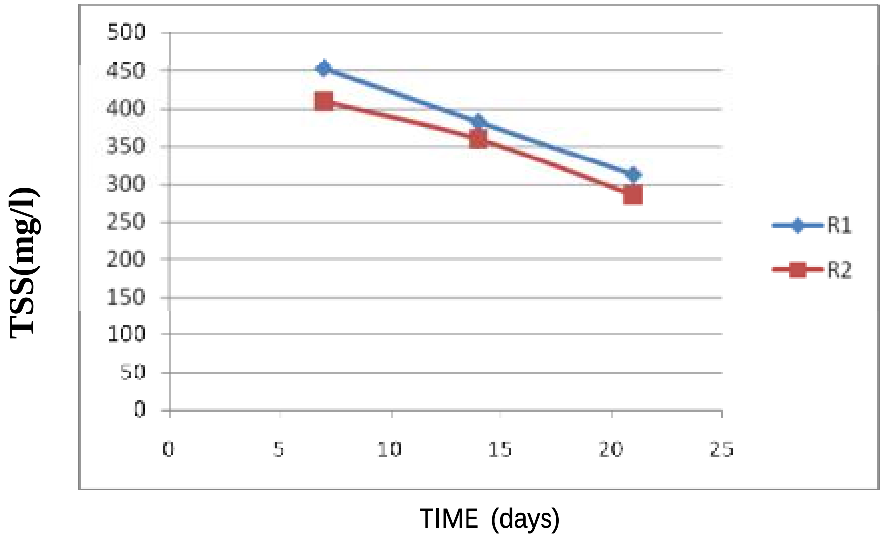

Figure (20)
TSS(mg/l) value of the industrial wastewater after treatment experiment(1) halvah factory.

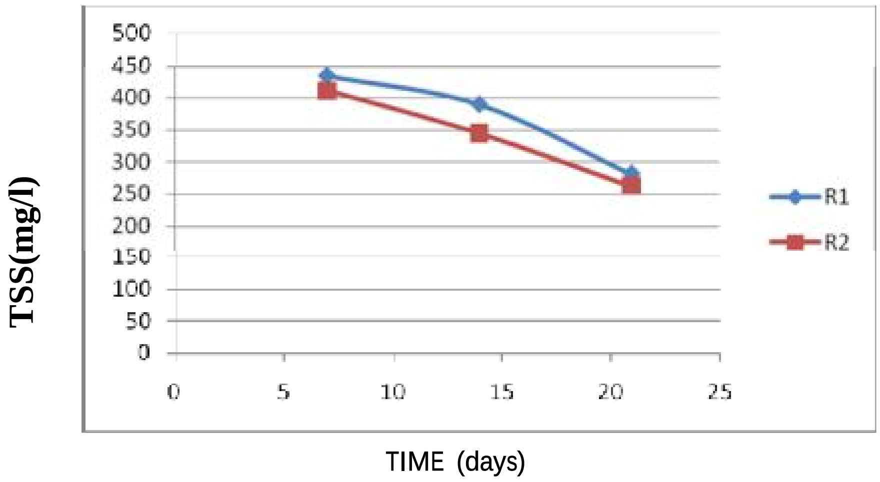

Figure (21)
TSS(mg/l) value of the industrial wastewater after treatment experiment(2) halvah factory.

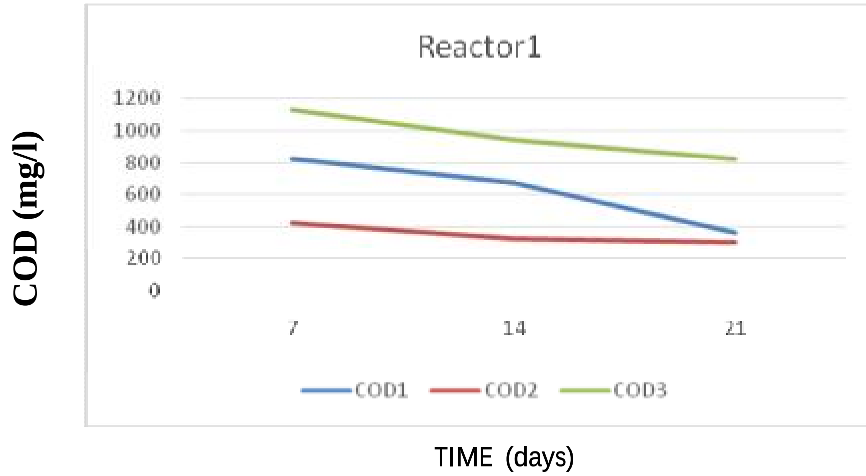

Figure (22)

COD(mg/l) value of the industrial wastewater effluent reactor1 after treatment for all experiments for clothes factory

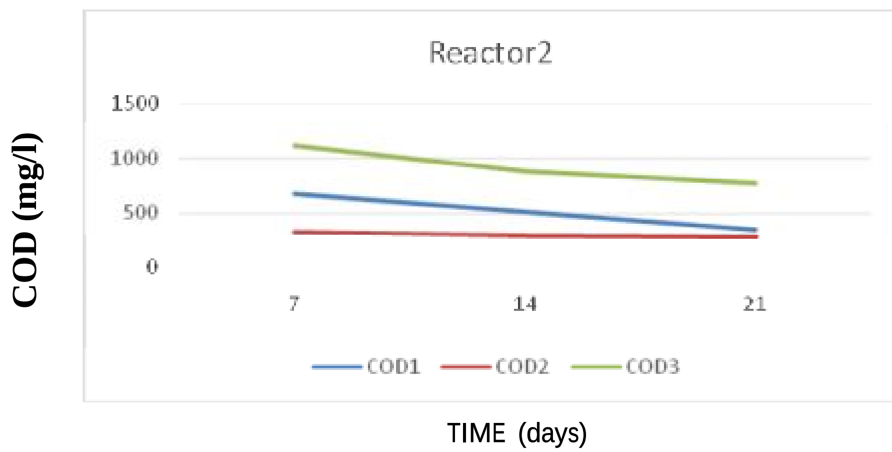

Figure (23)

COD(mg/l) value of the industrial wastewater effluent reactor2 after treatment for all experiments for clothes factory

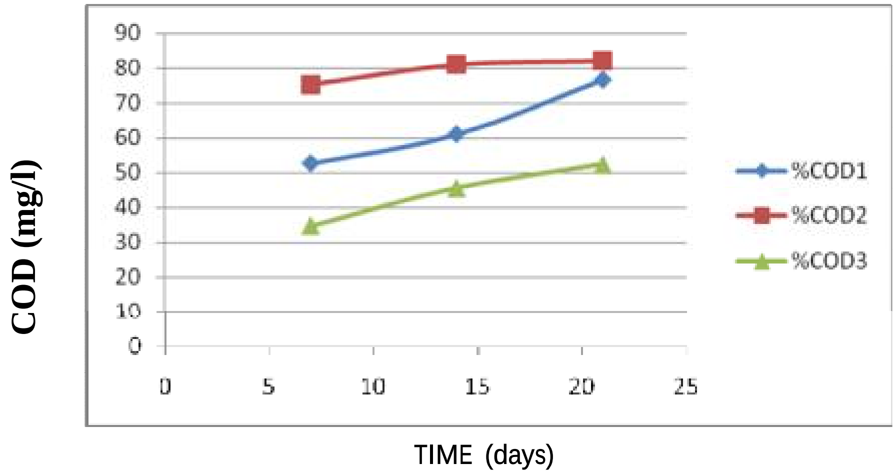

Figure (24)
Percentage removal value of COD(mg/l) of the industrial wastewater effluent from reactor1 after treatment for all experiments for clothes factory

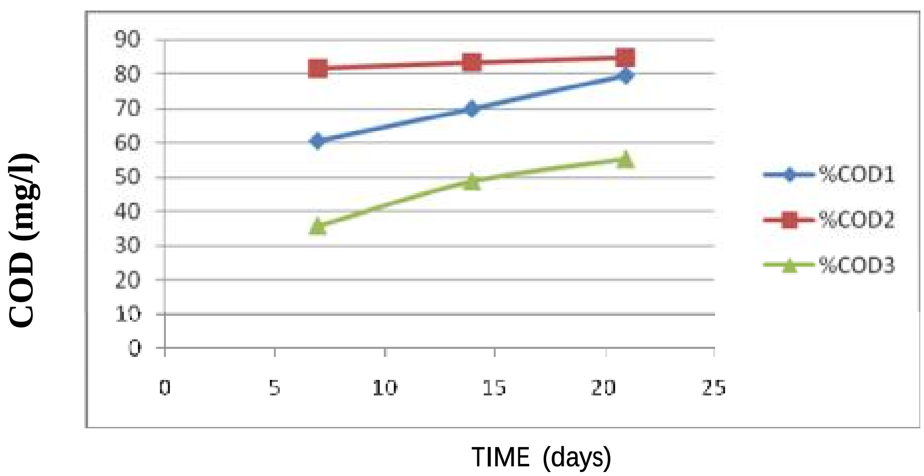

Figure (25)
Percentage removal value of COD(mg/l) of the industrial wastewater effluent from reactor2 after treatment for all experiments for clothes factory.

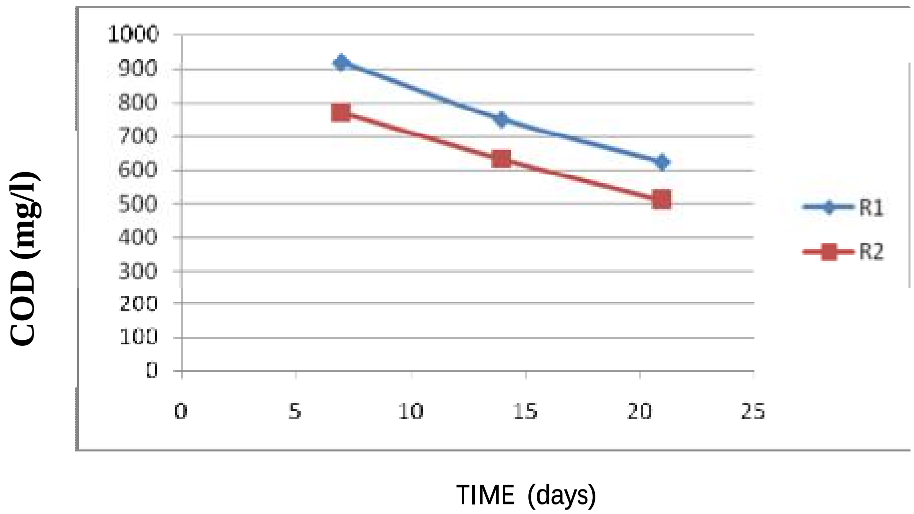

Figure (26)
COD(mg/l) value of the industrial wastewater effluent from anaerobic digester after treatment for experiment(1) for halvah factory

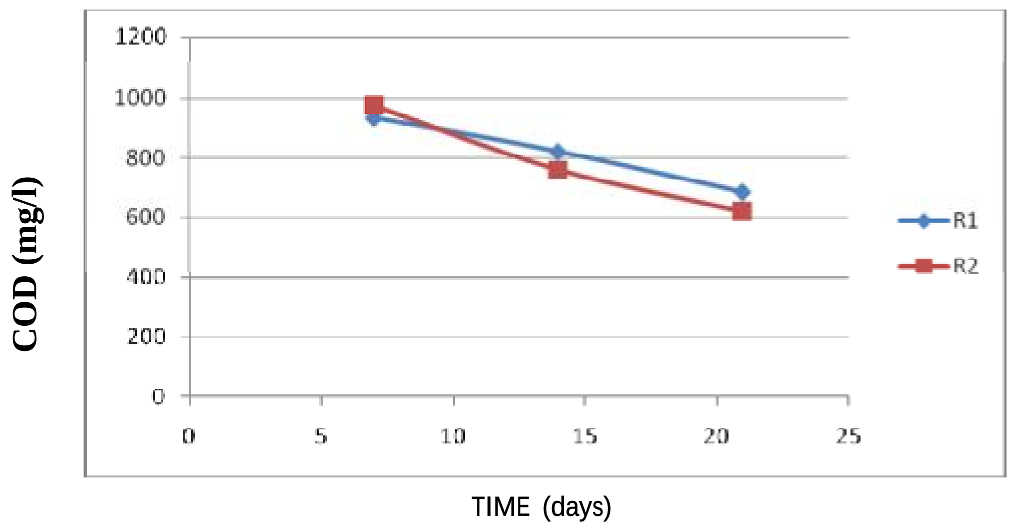

Figure (27)
COD(mg/l) value of the industrial wastewater effluent from anaerobic digester after treatment for experiment(2) for halvah factory

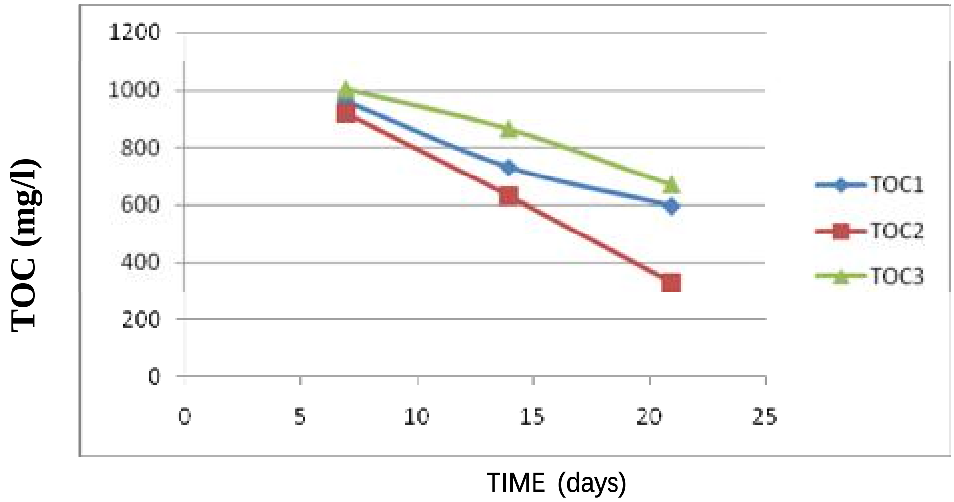

Figure (28)
TOC(mg/l) value of the industrial wastewater effluent reactor1 after treatment for all experiments for clothes factory

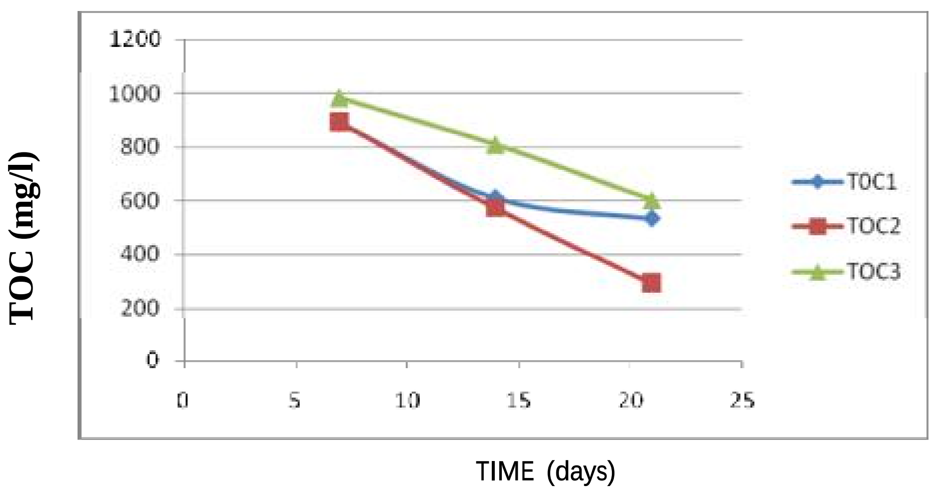

Figure (29)
TOC(mg/l) value of the industrial wastewater effluent reactor2 after treatment for all experiments for clothes factory

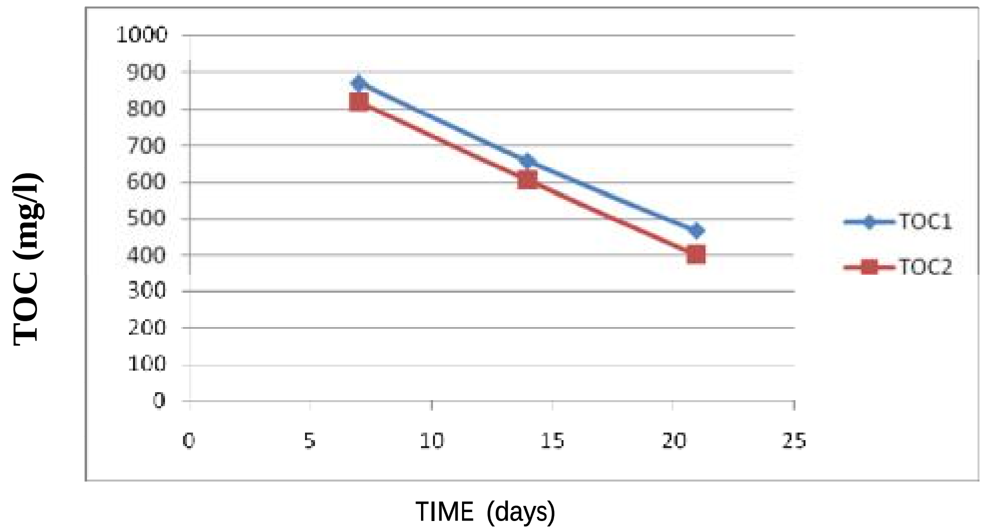

Figure (30)
TOC(mg/l) value of the industrial wastewater effluent reactor1 after treatment for all experiments for halvah factory

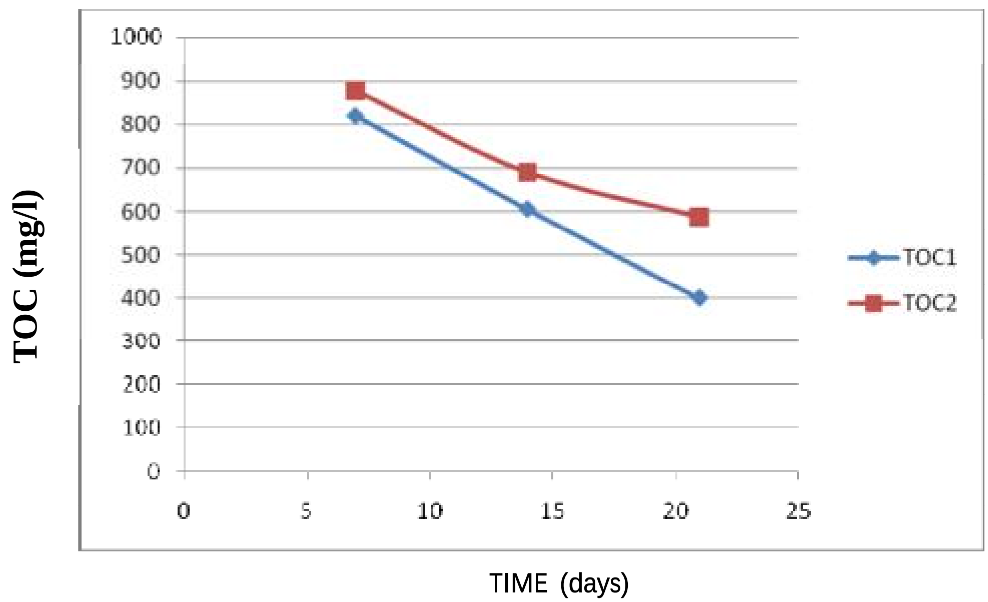

Figure (31)
TOC(mg/l) value of the industrial wastewater effluent reactor2 after treatment for all experiments for halvah factory

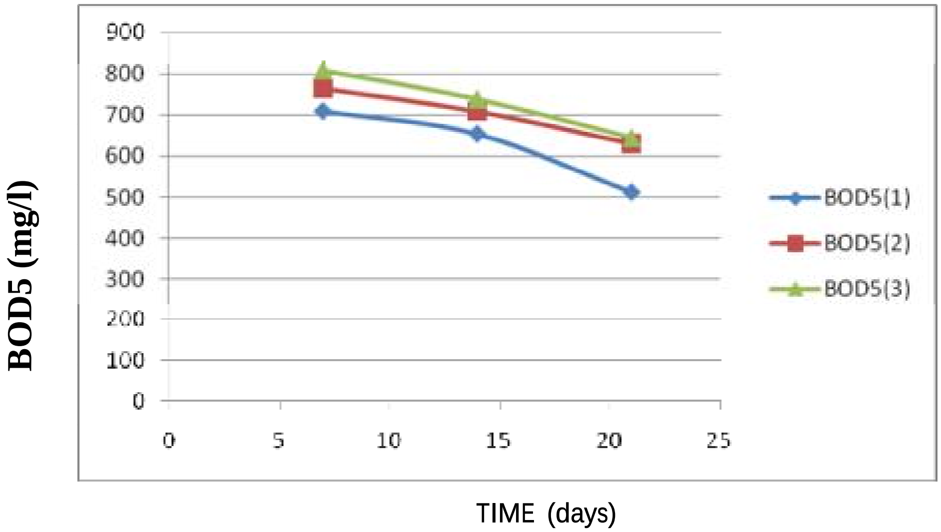

Figure (32)
BOD5(mg/l) value of the industrial wastewater effluent reactor1 after treatment for all experiments for clothes factory

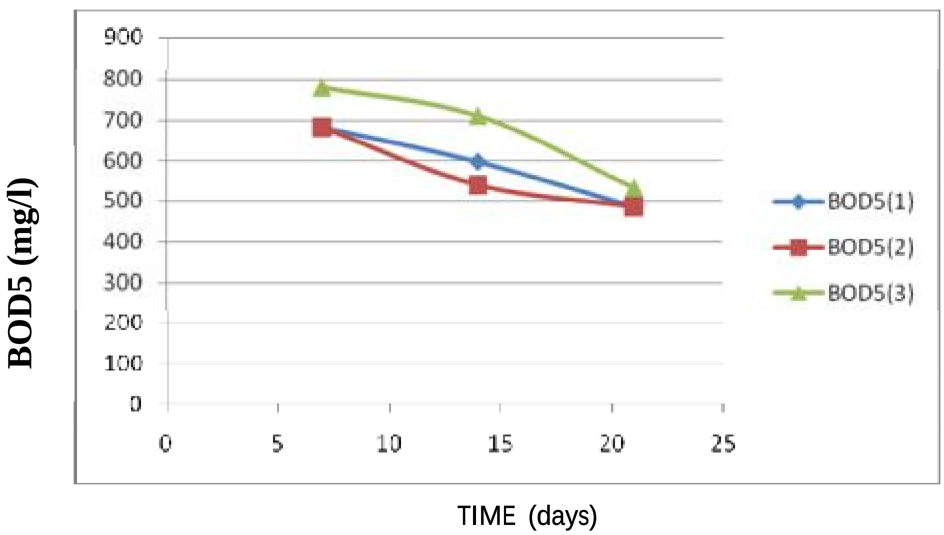

Figure (33)
BOD5(mg/l) value of the industrial wastewater effluent reactor2 after treatment for all experiments for clothes factory

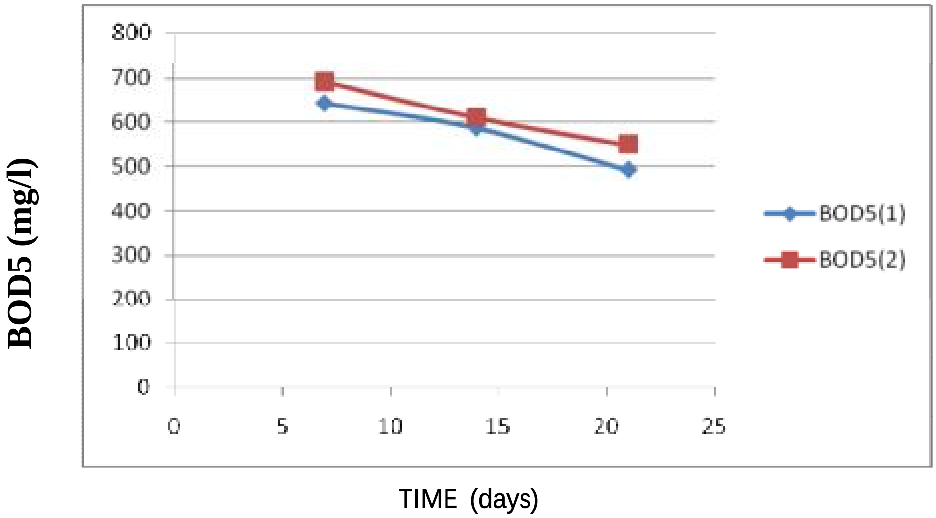

Figure (34)
BOD5(mg/l) value of the industrial wastewater effluent reactor1 after treatment for all experiments for halvah factory

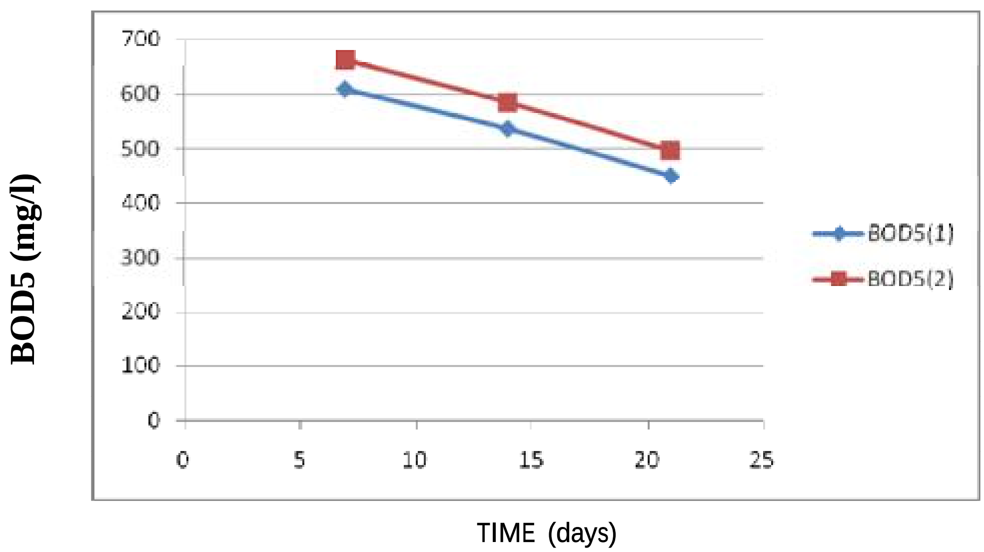

Figure (35)
BOD5(mg/l) value of the industrial wastewater effluent reactor2 after treatment for all experiments for halvah factory

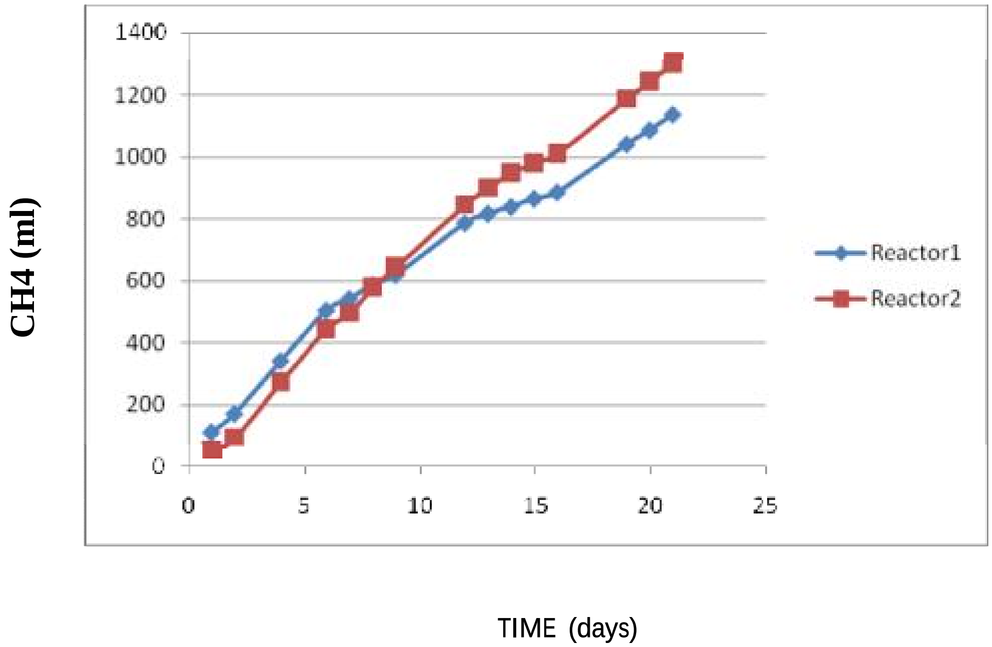

Figure (36)
CH4(ml) value of the industrial wastewater effluent after treatment for experiments (1) for clothes factory

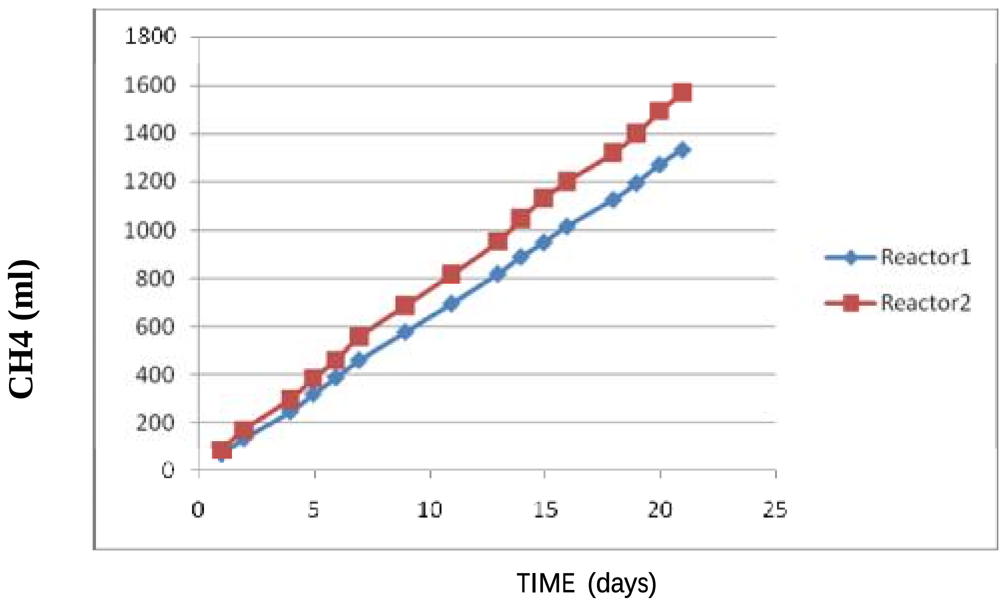

Figure (37)
CH4(ml) value of the industrial wastewater effluent after treatment for experiments (2) for clothes factory

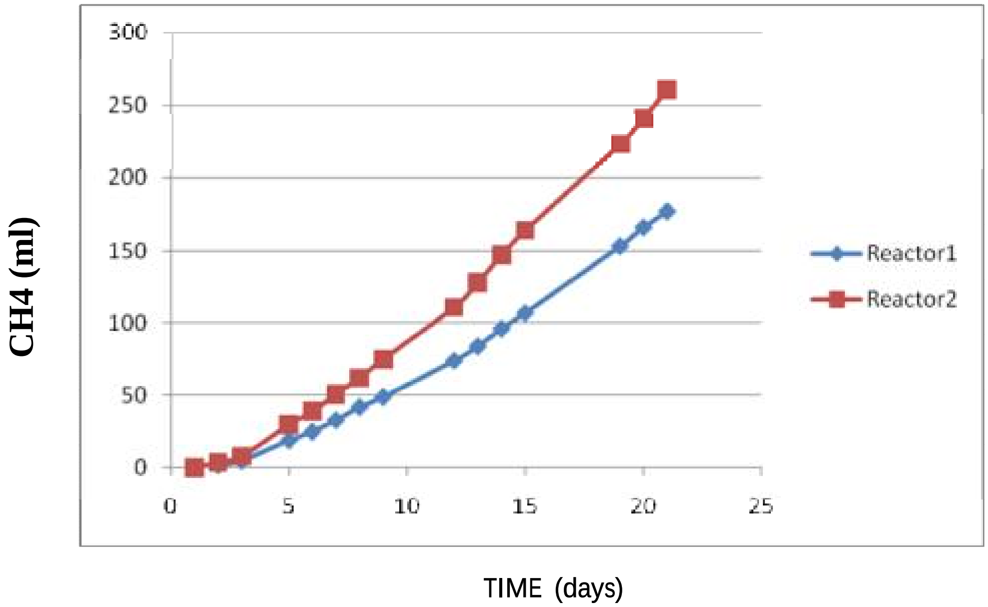

Figure (38)
CH4(ml) value of the industrial wastewater effluent after treatment for experiments (3) for clothes factory

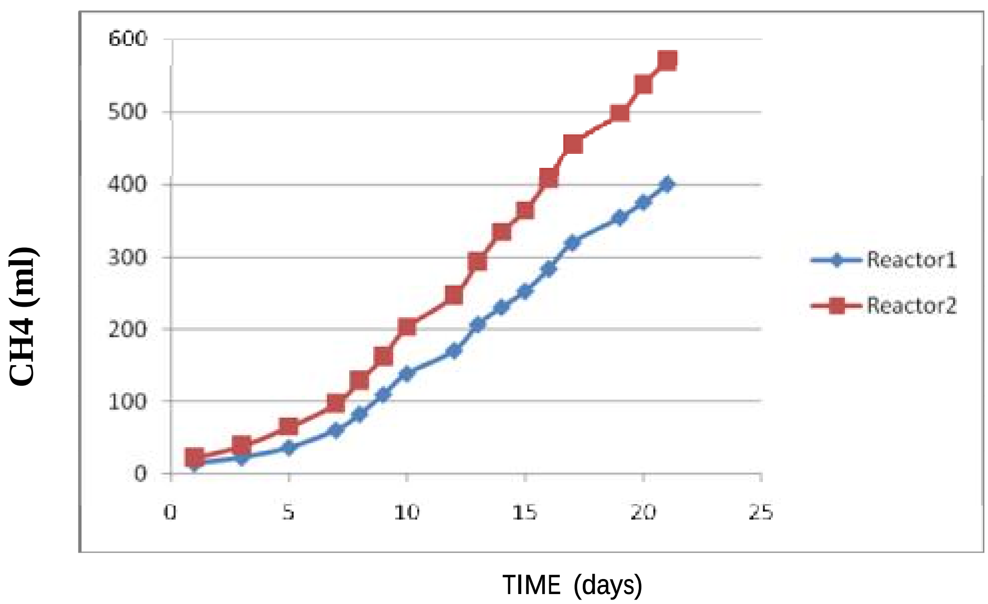

Figure (39)
CH4(ml) value of the industrial wastewater effluent after treatment for experiments (1) for halvah factory

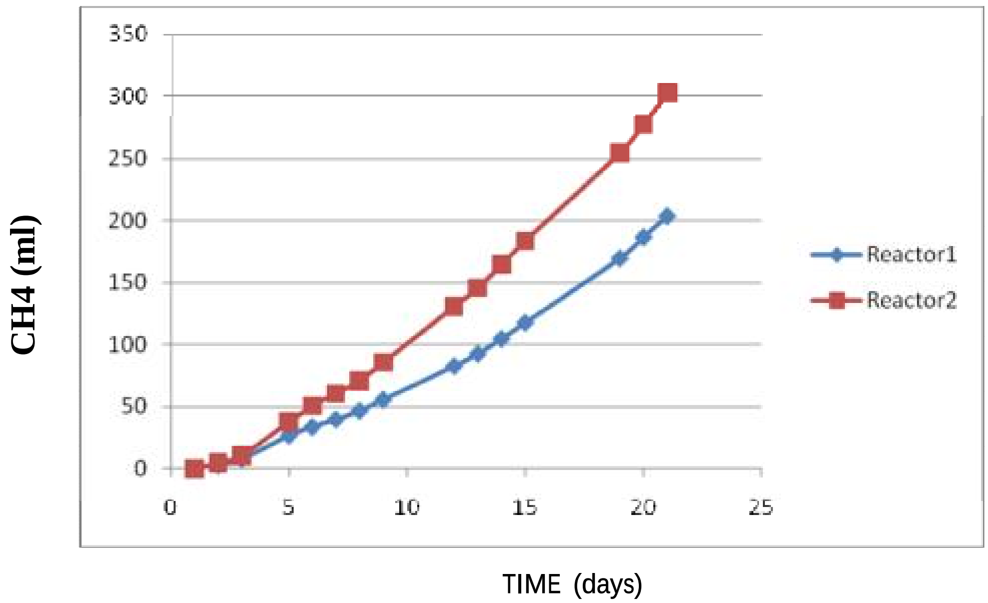

Figure (40)
CH4(ml) value of the industrial wastewater effluent after treatment for experiments (2) for halvah factory

Appendix (II)

Tables

Table (1) Interference from industrial discharges

Source	Pollutant	Effect On Treatment System
Metal Finishing and Printed Circuit Board Manufacture	A: Heavy Metals	Decrease or stop biological removal rates for secondary and anaerobic treatment. Prevent reuse of sludge or make it a hazardous waste.
	B: Chlorinated Solvents	Same effects as A. Exposure of POTW workers to toxic gas
	C: Acids	Destroy microbes, stopping treatment Upset anaerobic digester reducing gas production Corrode structures
Cleaning Operations (Machinery Repair, Food Process, Clean-in-place Operations)	D: Detergents	Foam in secondary treatment facilities reduces settling characteristics and dewaterability.
Oil Production, Refining or Dispensing	E: Oil	Interferes with settling . Toxic to anaerobic bacteria in large quantities reducing gas production. Explosive when using a pure oxygen activated sludge system.
	F: Flammables	Same effects as A. Explosive when it accumulates.
	G: Sulfide (Oil Production)	Toxic to treatment plant workers. Odor complaints Increases oxygen demand and blower requirements.
	H: Salt (Oil Production)	Decreases oxygen transfer efficiency Inhibits biological activity.
Food Processing	I: BOD (Soluble and Insoluble)	Increases oxygen demand in secondary treatment. May change microbiology of secondary treatment, causing secondary treatment settling

		problems. Creates odors.
Organic Chemicals (Ketones Alcohols)	J: Acetone, Methyl Ethyl Ketone, Isopropanol	If biological treatment microorganisms are acclimated, effects same as I-1 If biological treatment microorganisms are not acclimated, effects same as B.
Utilities (Steam, Electricity, Cooling Towers)	K: Temperature (Hot)	Depending on discharge point of POTW, exceed temperature limits. Change microbiology or biological treatment efficiency. Accelerate hydrogen sulfide production which causes odors and corrosion.

Table (2)

Physical parameter of effluent IWW from anaerobic digester for experiment (1) , clothes factory.

	Reactor (1)				**Reactor(2)**			
No. week	**Temperature (ºC)**	**TSS (mg/l)**	**TDS (mg/l)**	**TVS (mg/l)**	**Temperature (ºC)**	**TSS (mg/l)**	**TDS (mg/l)**	**TVS (mg/l)**
1	32.6	640	2248	1220	34.8	591	2211	1103
2	35.9	477	1847	981	37.8	411	1652	743
3	36.2	382	1689	733	38	279	1403	521

Table (3)

Physical parameter of effluent IWW from anaerobic digester for experiment (2) , clothes factory.

	Reactor (1)				**Reactor(2)**			
No. week	**Temperature (ºC)**	**TSS (mg/l)**	**TDS (mg/l)**	**TVS (mg/l)**	**Temperature (ºC)**	**TSS (mg/l)**	**TDS (mg/l)**	**TVS (mg/l)**
1	33.9	583	2055	1200	35.3	515	1945	981
2	36.8	420	1877	811	37.2	333	1650	660
3	37	296	1539	420	37.4	217	1347	333

Table (4)

Physical parameter of effluent IWW from anaerobic digester for experiment (3) , clothes factory.

	Reactor (1)				Reactor(2)			
No. week	Temperature (ºC)	TSS (mg/l)	TDS (mg/l)	TVS (mg/l)	Temperature (ºC)	TSS (mg/l)	TDS (mg/l)	TVS (mg/l)
1	31	633	2444	1112	32.3	562	2251	964
2	33.9	518	2170	982	35.2	425	1987	822
3	35.1	340	1980	780	36	290	1730	650

Table (5)

Physical parameter of effluent IWW from anaerobic digester for experiment (1) , halvah factory.

	Reactor (1)				Reactor(2)			
No. week	Temperature (ºC)	TSS (mg/l)	TDS (mg/l)	TVS (mg/l)	Temperature (ºC)	TSS (mg/l)	TDS (mg/l)	TVS (mg/l)
1	25.5	452	1977	1330	26.9	410	1902	1240
2	28.9	382	1751	970	31.6	360	1535	831
3	35	312	1520	630	37	285	1311	411

Table (6)

Physical parameter of effluent IWW from anaerobic digester for experiment (2) , halvah factory.

	Reactor (1)				Reactor(2)			
No. week	Temperature (ºC)	TSS (mg/l)	TDS (mg/l)	TVS (mg/l)	Temperature (ºC)	TSS (mg/l)	TDS (mg/l)	TVS (mg/l)
1	29.3	435	2040	1245	30.4	411	1982	871
2	32.8	390	1907	811	33.5	344	1811	660
3	34.5	281	1846	590	36	262	1792	422

Table (7)

Chemical parameter of effluent IWW from anaerobic digester for experiment (1) , clothes factory.

	Reactor (1)					Reactor(2)				
No. week	pH	EC µs/cm	COD (mg/l)	BOD5 (mg/l)	TOC (mg/l)	pH	EC µs/cm	COD (mg/l)	BOD5 (mg/l)	TOC (mg/l)
1	6.5	1450	820	690	961	5.8	1442	681	482	890
2	6.1	1233	674	655	730	5.5	1003	520	397	610
3	5.8	961	513	370	595	5.2	730	485	290	533

Table (8)

Chemical parameter of effluent IWW from anaerobic digester for experiment (2) , clothes factory.

	Reactor (1)					Reactor(2)				
No. week	pH	EC µs/cm	COD (mg/l)	BOD5 (mg/l)	TOC (mg/l)	pH	EC µs/cm	COD (mg/l)	BOD5 (mg/l)	TOC (mg/l)
1	6.2	1121	766	430	955	5.5	935	682	320	896
2	5.8	874	710	330	631	5.2	626	541	290	572
3	5.3	652	631	310	327	5.2	410	487	282	290

Table (9)

Chemical parameter of effluent IWW from anaerobic digester for experiment (3) , clothes factory.

	Reactor (1)					Reactor(2)				
No. week	pH	EC µs/cm	COD	BOD5	TOC	pH	EC	COD	BOD5	TOC
1	6.6	1420	1130	692	1030	6.2	1388	1112	580	985
2	6.1	1112	942	640	866	5.8	970	887	411	810
3	5.9	911	825	545	670	5.7	751	774	382	603

Table(10)

Chemical parameter of effluent IWW from anaerobic digester for experiment (1) , halvah factory.

	Reactor (1)					Reactor(2)				
No. week	**pH**	**EC µs/cm**	**COD**	**BOD5**	**TOC**	**pH**	**EC**	**COD**	**BOD5**	**TOC**
1	6.7	1090	920	644	871	6.2	922	772	610	820
2	5.9	845	751	588	657	5.5	771	633	537	605
3	5.4	650	625	492	466	5.2	580	511	450	400

Table(11)

Chemical parameter of effluent IWW from anaerobic digester for experiment (2) , halvah factory.

	Reactor (1)					Reactor(2)				
No. week	**pH**	**EC µs/cm**	**COD**	**BOD5**	**TOC**	**pH**	**EC**	**COD**	**BOD5**	**TOC**
1	6.5	1020	993	692	921	6.1	903	977	663	879
2	5.7	825	821	611	730	5.3	726	762	586	691
3	5.5	614	685	549	610	5.2	511	622	497	588

Table(12)

CH4 (ml) accumulated of effluent from anaerobic digester for all experiment , clothes factory.

	Experiment (1)		Experiment (2)		Experiment (3)	
Time (day)	**Reactor 1**	**Reactor 2**	**Reactor 1**	**Reactor 2**	**Reactor 1**	**Reactor 2**
1	112	51	66	82	0	0
2	172	92	136	171	2	4
4	343	273	248	298	5	8
6	506	445	320	385	19	30
7	544	496	389	460	25	39
8	589	579	461	556	33	51
9	621	645	578	687	42	62
12	788	846	697	816	49	75
13	819	901	820	953	74	111
14	841	948	891	1047	84	128
15	867	981	951	1131	96	147
16	888	1012	1017	1202	107	164
19	1043	1188	1127	1321	153	223
20	1088	1245	1196	1401	166	241
21	1139	1303	2608	3064	177	261

Table(13)

CH4 (ml) accumulated of effluent from anaerobic digester for all experiment , halvah factory.

	Experiment (1)		Experiment (1)	
Time(day)	**Reactor (1)**	**Reactor (2)**	**Reactor (1)**	**Reactor (2)**
1	15	22	0	0
3	23	39	3	5
5	37	65	8	11
7	61	97	27	38
8	83	129	34	51
9	110	162	40	61
10	139	203	47	71
12	171	247	56	86
13	207	294	83	131
14	231	335	93	146
15	253	365	105	165
16	284	409	118	184
17	320	456	170	255
19	355	498	187	278
20	376	539	204	303
21	401	571	244	327

Table (14)

Statistical of factories in AL-Hussein Bin Abdullahll Industrial City .

Factories	Industrial	Flow (m3/day)
Global Camel Manufacturing Co. Knits	Clothes	70
Zaytuna company for the manufacture of ready-made clothes	Clothes	85
AL-Faluk company for the manufacture of ready-made clothes	Clothes	55
Higher factory for cosmetics	Chemical	40
Tgarb for the manufacture of paints and minerals	Construction	0
Ready Mix Concrete and Construction Supplies Company	Construction	120
Kam Sham Food Industries Company	Food	78
Mujahid Qaraqe Foundation	Food	15
Nasser Thunaibat & Partner Factory	Plastic	10
Mustafa Abu Hamayor company	Food	22
Aman Pharmaceutical Industries	Pharmaceutical	45
Moataz factory Aldjaafarh	Food	37
Ahmed Ghassan Thunaibat plastic factory	Plastic	18
Jordanian industry Chalk	Chemical	10
Hiam Abu Kadira a factory for dairy products	Food	20
Coca-Cola Company food	Food	130
Munir Alackerma Food Industries Co.	Food	22
Yamamah water bottling plant	Food	30
AL-Maged for the manufacture of halva	Food	12
Golden Gate for the manufacture of shampoo and soap	Chemical	112
Constants for recycling fabrics and fillings industry	Clothes	0

Table (15)

Allowable Jordanian Standard (2006) limits for effluent industrial wastewater from factories quality parameters .

The standards	The symbol	Limit allowed (mg/l)
Biological oxygen demand(five days)	BOD_5	500
Chemical oxygen demand	COD	1000
Dissolved oxygen	DO	
Total suspended solid	TSS	300
Negative logarithm of H^+ concentration	pH	From 6.5 to 9
Nitrate	NO_3	
Total nitrogen	T-N	
Escherichia coli	E.coli	
Intestinal Helminthes Eggs	Intestinal Helminthes Eggs	
Fat, Oil and Grease	FOG	50
Phenol	Phenol	0.002>
Methylene Blue Active Substance	MBAS	26
Total Dissolved Solids	TDS	2000
Phosphate	P(as PO_4)	15 /
Chloride	CL	500
Sulphate	SO_4	300
Bicarbonate	HCO_3	400
Sodium	Na	400
Magnesium	Mg	60
Calcium	Ca	200
Sodium Adsorption Ratio	SAR	9
Aluminum	Al	5
Arsenic	As	0.1
Beryllium	Be	0.1
Copper	Cu	2
Fluoride	F	2
Iron	Fe	5
Lithium	Li	2.5
Manganese	Mn	0.2
Molybdenum	Mo	0.01
Nickel	Ni	0.2
Lead	Pb	1
Selenium	Se	0.05

Cadmium	Cd	0.07
Zinc	Zn	15
Chromium	Cr	0.3
Mercury	Hg	0.001
Vanadium	V	0.1
Cobalt	Co	0.05
Boron	B	1
Cyanide	CN	0.3

المعلومات الشخصية

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